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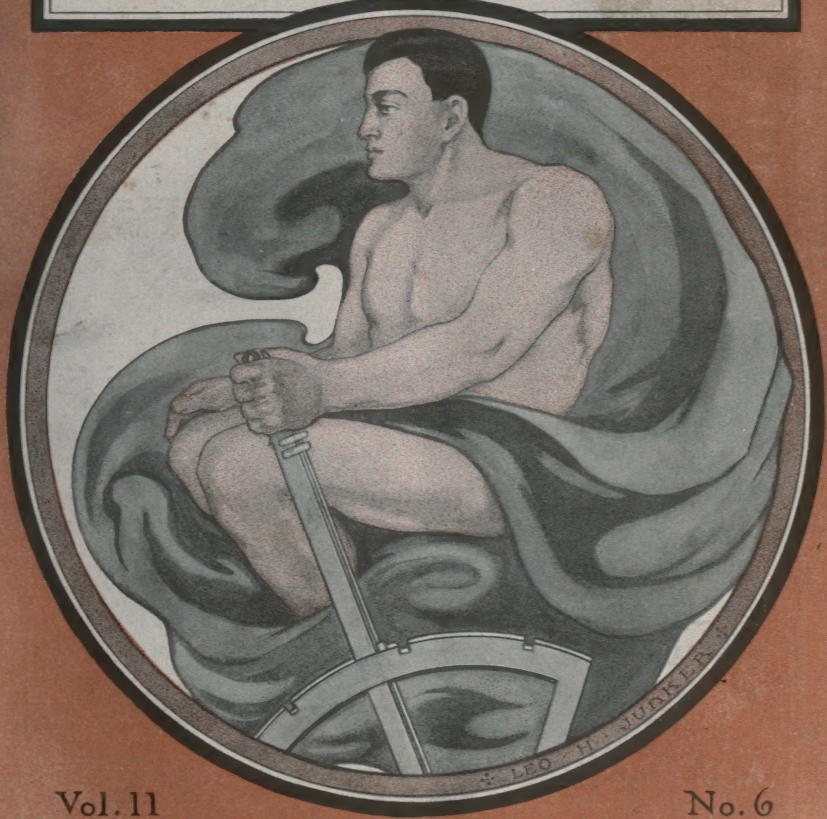

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THE

Technical World Magazine

VOLUME II

September, 1904—February, 1905

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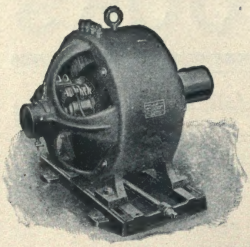

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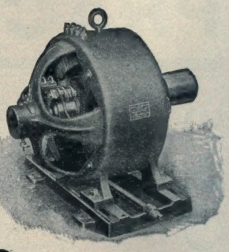

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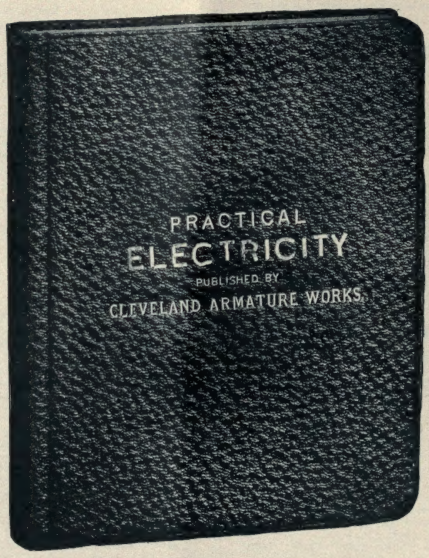

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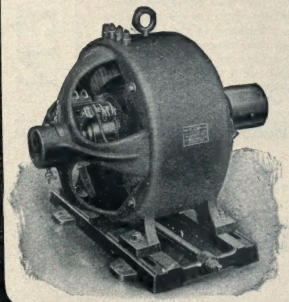

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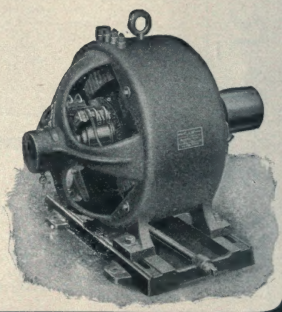

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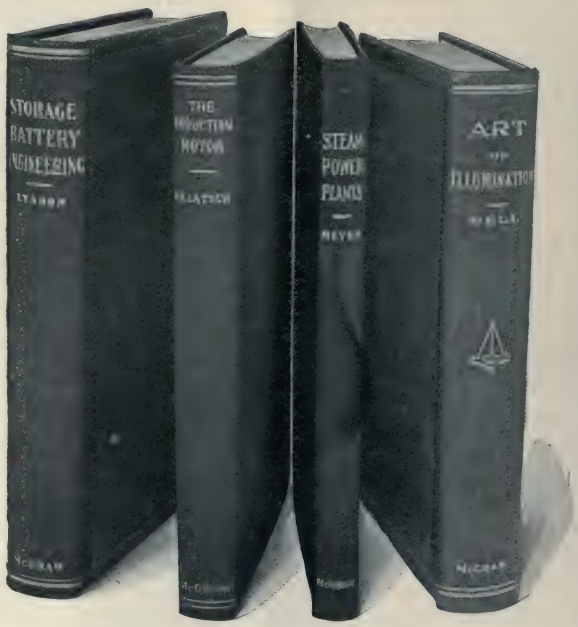

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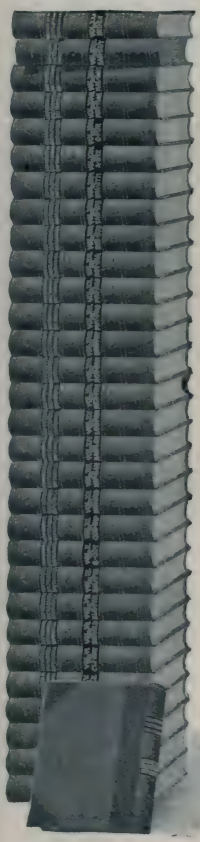

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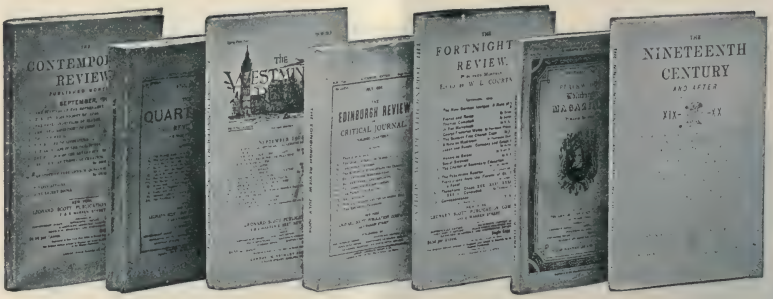

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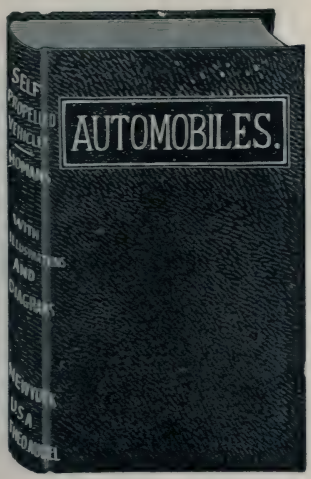

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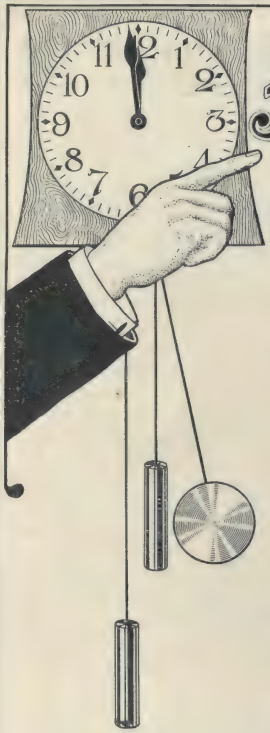

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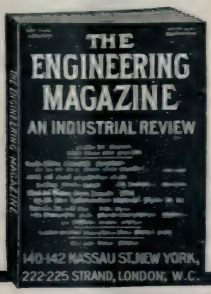

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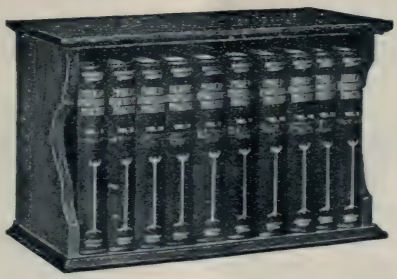

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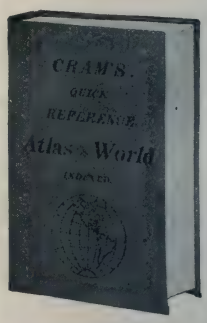

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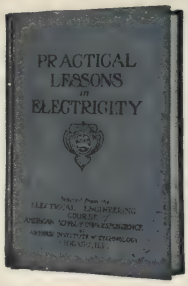

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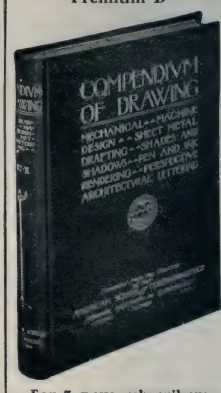

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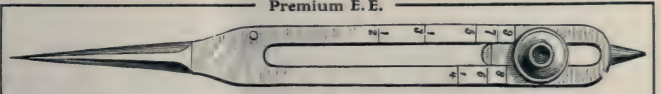

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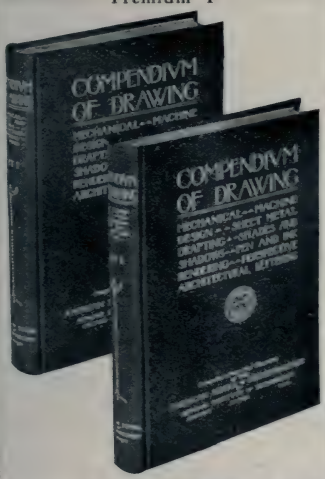

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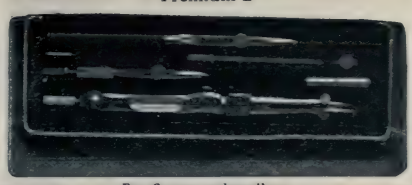

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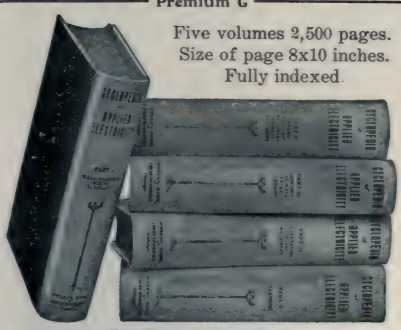

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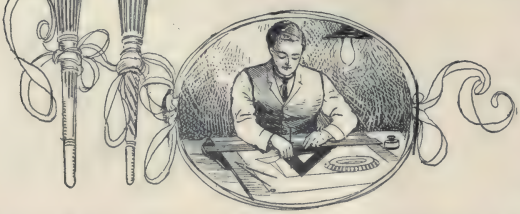

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During the little more than a year in which the work has already been under

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way, not a single passenger has been incommoded on account of it; passengers, indeed, would not even know of it unless they should glance from the car windows; but if they thus glance out, they see a great extent of torn-up ground, and an army of men busily at work among rock-drills, long-armed derricks, shored-up buildings, temporary bridging, and scaffolded sidewalks.

A New Terminal Needed

For years the need of more commodious and differently arranged terminal facilities has been recognized, to accommodate the increasing traffic and give a higher degree of comfort and safety. The problem facing the New York Central and the New York, New Haven & Hartford has been a serious one, and for years the foremost engineering minds have been applied to its solution. Important improvements were not long ago made, including the material enlargement of the present station; but it was soon seen that the improvements were insufficient, and that far more radical changes needed to be made.

The territory over which these needed changes are to extend has been divided into three longitudinal sections; and while work is going on upon one of these sections, the other two are utilized to their fullest capacity. Simply stated, that is how non-disturbance of traffic is attained; but the simple statement gives no idea of the difficulties encountered. One needs to stand for a while in the terminal yards, and watch the ceaseless movement of trains, to gain some adequate impression of the perplexities of the problem.

Each day there are 640 trains arriving or departing; each day there are over 7,000 pieces of baggage handled; each day 300 tons of mail and 600 tons of express matter enter or leave the terminal. And it is traffic such as this which goes on undisturbed, and is to continue to go on undisturbed.

"Structures overhanging the tracks." —"Long lines of scaffolded sidewalk."

The Work of Many

The work is of notable interest, in that it does not come from the plans of any one man. The ideas of perhaps a dozen engineers have been merged in one result. For years, there have been examination, discussion, tentative decision; plan after plan has been raised up, only to be cast down; and experts have worked unitedly and in harmony towards the goal. There has been the most friendly emulation; there has been cordial rivalry as to who

should hit upon the best and most practicable features; there has been partial acceptance, partial rejection.

There has, indeed, been one man at the head—Mr. William J. Wilgus, who was Chief Engineer of the New York Central when the consideration of these improvements was taken up, and who has since been promoted to one of the vice-presidencies. With him has lain most of the final decision as to practicability and usefulness; with him have originated many of the ideas; with him is the general control; and he is most ably seconded.

"Not from every point can the extent of trackage be guessed."

The Path of Destruction

It was early recognized that the terminal yards would need to be enlarged in breadth, and so the purchase and demolition of houses was begun. The location of the station in the very center of the great city, with large buildings close-hemming the yards on either hand, made this first item an expensive one. Numerous large structures stood in the path of destruction. In all, nearly two hundred buildings have been destroyed, including churches, hospitals, apartment houses, and private homes.

"Elaborate shoring under bordering buildings."

Even at the beginning of the work, there was a bewildering maze of tracks; but when all is completed there will be, approaching the new station, a fan-shaped widening into 53 tracks; and into the station itself, on the main track level, there will be 19 tracks abreast. All of these tracks are to be depressed 12 feet below the present level; and the narrow footbridges which cross the yards at a considerable height above the present tracks will be replaced by broad structures for wagons

PART OF TRACKAGE CENTERING AT GRAND CENTRAL STATION, NEW YORK.

All this "maze of tracks" is being depressed and tunneled, to accommodate the electric train service which alone will enter and leave the new terminal.

and pedestrians alike, at nearly the level of the streets on either hand

Scattered throughout the great stretch of trackage there will be switches and curved tracks and turntables; and underneath the vast tangle, there is to be, for the service of suburban traffic, a subway, with eight tracks abreast, which is to run right under the new station and to connect there with the great subway service of the New York streets. And for suburban passengers, in the new station, there is to be a great waiting room, on the level of the subway tracks, directly beneath the waiting room for the long-distance trains.

For the upholding of the network of tracks above the suburban subway, there will be supports of massive steel construction. But massiveness is an incident of all this work. Even the temporary itself is massive. The subway portion is to be mainly through the solid rock, and the tunnel will be lined with concrete on both the bottom and the sides.

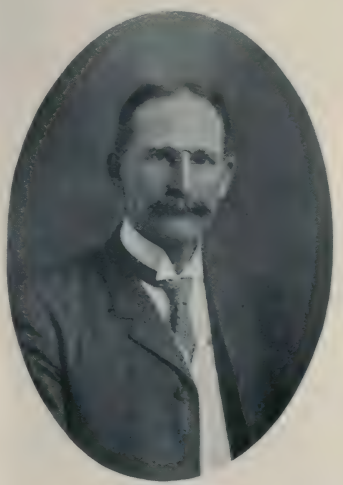
The Personal Equation

Quite as interesting as the work itself, full of interest though that is, are the personality and history of some of the men connected with it—a man who educated himself by means of a correspondence school; another, who was draftsman for a builder of boats, to earn money for an education; two architects who were called to New York from distant Minnesota for this special service; a contractor of eminent success, whose technical education was obtained at night because he had to work for his living every day.

The man who is in charge of the huge preparatory work; whose generalship and skill are clearing away the buildings, tunneling the rock, and constructing foundations, is Mr. John F. O'Rourke, a man still under fifty, but at the head of a company which has already carried out works of great importance, including bridge and tunnel work and the laying of foundations of numbers of the largest sky-scrapers of New York.

And what encouragement there is in his career! After receiving an ordinary degree of education in a New York school, it was necessary for him to go to work; and he did so, although his ambition was keen for an education in technical branches. But while he worked by day, he studied by night. He entered himself as a pupil at Cooper Union; and, studying with keenest application, went through with its engineering course. He knew that the course at the great technical schools was beyond him, but in spite of that he was determined to succeed.

For a time, after his course was completed, he continued to work for others; but before long, with what would seem an absurdly small equipment to face



Arthur B. Corthell.
Terminal Engineer.

the world, he started in business for himself. From small beginnings he rapidly rose. His skill and energy forced recognition. He began taking more and more important contracts, and each one was carried to a successful completion. He was taken into the fellowship of the American Society of Civil Engineers, this product of night work, this overcomer of difficulties; and his career shows to young men the importance of seizing upon the means nearest at hand, and not idly lamenting because the usual means are beyond reach. It was a favorite axiom of Napoleon, that the true proof of high ability is to win in spite of difficulties, and to make use of whatever can be seized upon.

"In the midst of the desolated space."

A Complicated Problem

The problems confronting the engineers in this work at the Grand Central are of wide variety. It would be hard to think of any branch of engineering and scientific skill which is not to be called upon in some branch of the work or in some stage of its progress.

The problem of handling water and gas and sewer pipes has not been among the smallest, for there has had to be a complete change of this system of piping crossing the terminal area. There are great gas mains, carried on temporary bridging above the tracks, and forming gigantic "U's" in rejoining their connections. Water pipes are dislodged and set down in new locations. The manage-

AN ENGINEERING SQUAD AT WORK.

ment of several great sewers which the work disturbed, has had to be carefully planned.

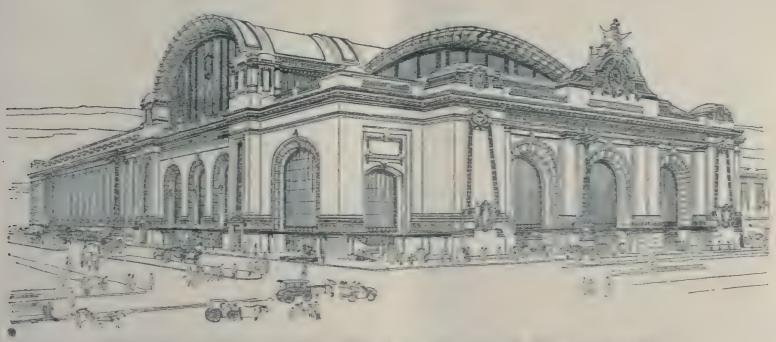
The foot-passengers crossing the yards must be cared for; and so there are temporary structures erected above the tracks. The excavations have so encroached upon other property, besides those buildings which have been destroyed, that, overhanging the tracks, there are long lines of structures under which elaborate shoring has been placed, and where a single miscalculation would send them toppling down. But it is characteristic of Americans, that the people live quite comfortably in these braced-up buildings and with as full a sense of confidence as if they were upon their

tions, to hoisting engines and other machinery. In every detail there is utilization of the most modern methods. And a thousand men are daily working there.

The Terminal Engineer

The man who, under the title of "Terminal Engineer," is in active charge of all this work, has had a history which should serve as deep encouragement to all who are ambitious against odds.

Mr. Arthur B. Corthell, upon whom devolves most of the direct superintendency of the work of construction, is still under forty-five, and he has won high success. As a young man, it was his ambition to follow a scientific career: but it was impossible for him to be sent



PROPOSED GRAND CENTRAL TERMINAL STATION OF NEW YORK CITY.

For the New York Central & Hudson River Railroad Company.—Warren & Wetmore and Reed & Stem, Associate Architects.

original foundations. Such little things are among the necessary incidents of American progress, and so the occupants give the matter no concern.

In the midst of the desolated space, bordered in places by long lines of scaffolded sidewalk, giant derricks swing their arms, and drills eat their way into the heart of the rock. Steam shovels, each of which, working under difficult conditions, can fill forty 30-yard cars in ten hours—buckets which can pick up five yards of rock at a lift—such are some of the appliances. Air-compressors, with a capacity of 5,000 cubic feet a minute, supply air at one hundred pounds' pressure, through a ten-inch main with branches and flexible connec-

to one of the technical schools in the usual way. But, impressing the famous yacht-builder, Herreshoff, with his ability, he obtained a situation as draftsman in the latter's office, with the privilege of keeping up at the same time the course in engineering at Brown University. It is interesting, in view of Herreshoff's more recent and more important fame, to know that for some time the stripling, Corthell, was the only draftsman in his office.

Brown University would not—at least at that time—be chosen for the fulness and importance of its scientific course; but it was only fifteen miles from the Herreshoff yards, and so young Corthell was wise enough to take advantage,

PORTION OF THE YARDS AND ENVIRONMENT OF THE GRAND CENTRAL TERMINAL, NEW YORK.

"*In the very heart of the great city.*"

thankfully, of the best attainable, rather than to repine over the impossibility of having the ideally best.

Graduating from Brown, Corthell looked for a wider field than yacht building could offer, and he gravitated naturally to railroading. Within five years after his graduation, he was in charge of important work for the Missouri Pacific system; he became known in Kansas, in Colorado, in Iowa; and then, called to the East by powerful New England interests, he was in charge, successively, of various large works, until 1902, when he was recognized by the New York Central as a man whom it must have. To him, more than to any other individual, is owing the accepted plan for the depression, tunneling, and arrangement of the tracks approaching the terminal. In common with others, he was closely studying the problem; and the solution came to him, when it came, overnight.

Electrification

The electrification of the trackage territory of the lines leading into the terminal area, for a distance of some twenty-five miles from the station, is the most important single feature of the general plan. When the improvements are completed, not a train will enter the Grand Central territory under steam power. Not only are the suburban trains to be operated by this force, within the electrical area; but the swift express trains from distant points will, as they approach the city, dismiss their steam locomotives, and be taken in charge by electric locomotives.

For the first time, electricity is to show its capacity to draw heavy express trains, of from 500 to 800 tons, at a speed of sixty miles an hour. Railroad men look upon this—and justly—as marking the beginning of a new epoch in the history of transportation. It is considered to be the beginning of a possibly unlimited electrification of the railroads of the country. It is deemed not improbable that from this as a beginning electricity will displace steam as a motive power for trains.

The enormous electric locomotives, the pioneers of this class of service, are odd-looking to our unaccustomed eyes, double-ended, and of 2,200 horse-power. The locomotives will be equipped with a new type of gearless, direct-current, bipolar motors. The entire weight of a locomotive will be not much more than half that of the huge steam locomotives of the largest type; but, whereas the 150-ton steam locomotive has but 47 tons on its two pairs of drivers, the electric locomotive will have 67 of its 85 tons borne on four pairs of drivers. Thus a surprising gain will be made in weight available for traction, and a great gain in the decrease of dead weight. In addition, experts point out that there will be an entire absence of counterbalancing of drivers and twist from reciprocal motion.

"Water pipes are dislodged."

Electric locomotives are to be used for long-distance trains only. For service from points within about twenty-five miles, there will be an equipment of multiple-unit controlled motors.

In the immediate approaches to the terminal, electricity has for some time past, been called for, by the necessities of the case and the demands of the city

government, to avoid the danger to life, and the loss of comfort, which arise from the blinding clouds of smoke and steam in the present tunneled approach through the city; and, while making the necessary degree of alteration, a broad policy dictated also the change, far more sweeping,

"The crossing foot-passenger must be cared for."

which should establish the use of electricity throughout the twenty-five mile area.

There are to be two power stations for the New York Central, one on Long Island Sound and one upon the Hudson, with ultimate capacity of 40,000 horsepower each. They will be cross-connected, and either one will be able to handle the entire traffic in case of the disabling of the other. And it is interesting, as showing the interdependence of traffic in these modern days, that these great power stations for land transportation are located at points upon the water, so as to be accessible by boat as well as by rail for the receipt of fuel.

A point very interesting to engineers, is that, at these power stations, the usual reciprocating engines will not be used, but there will be turbo-generators, of 7,500 horse-power, of the Curtis type. It is also of interest to note that, for these power stations, water-tube boilers have been adopted, in units of 625 horsepower each, equipped with internal superheaters which will generate steam at a pressure of 200 pounds and superheated to 200 degrees.

Another Master Mind

The myriad problems to be solved in the electrical branch of the improvements, gave occasion for another exhibition of the policy which has operated throughout the entire work—that of the utilization of the skill and knowledge of a number of men working in harmony. For a commission, consisting of some half dozen engineers, has been studying all the points involved, and regularly meeting for the final comparison and decision. The chairman of this commission is Mr. William J. Wilgus.

The career of Mr. Wilgus, who is in general charge of the entire work and to whom it is owing, more than to any other one man, that it has been carried so far toward successful completion, is of special interest. Born in Buffalo, N. Y., in 1865, he was enabled to pursue the grammar school and high school courses in that city, but found himself unable to take the technical course for which he felt a keen desire. But he was not of the stuff of which failures are made. He did not lamely repine that he must forego his ambitions because of insurmountable obstacles. He studied civil engineering in Buffalo, and worked with concentrated determination through the course of a correspondence school of Cornell University, which at that time had begun to give a correspondence course in engineering. The hektographed sheets of that period were his passport to success.

His course over, he looked about for engineering work. The Northwest attracted him; and in St. Paul he found his first success—a mild success only, for it gave him but the position of rodman. It was, however, the entering wedge with which he was to split the rock of achievement. There seems to be something in Minnesota air that is particularly favorable to the recognition and development

"These braced-up buildings."

of railroading ability; many a high official, and even several of the presidents of the most important roads of to-day, including the New York Central, have had the benefits of St. Paul railroad training.

Mr. Wilgus made himself invaluable, and within six years had won such a reputation that he was called to Chicago to become the resident engineer of the Chicago Union Transfer Railway. The next year saw him with the Duluth & Iron Range. And in 1893 he was drawn to the New York Central, which is forever on the lookout for the very best men obtainable. He had applied to this road for employment immediately after securing his correspondence school diploma; his home town being the western terminal of the road, it seemed the natural course for him to go to work for it; but the road was not ready to recognize the stripling, who, within so few years, was to come back from the West and take such important charge of its work.

One of the truths which a man who is to win any degree of success must know, is that there is always something to learn. Too many graduates of technical schools are too satisfied, at graduation, that they "know it all;" and it is for that reason that such men are often passed in the race by those who had far less advantages at the beginning.

Mr. Wilgus is one who knows that, for any man, there is always something to learn; and therefore it was, that, while engaged in engineering work at Chicago, he took up the profound study of electricity, and especially of electric appliances and apparatus. To that fact is owing his most marked advancement, for a master of engineering who is at the same time a master of things electrical is what the New York Central needed for the vast work which is to build the new trackage and station and install the operation of electricity.

With the New York Central, Mr. Wilgus rose rapidly, till be became Chief Engineer; and his recent promotion to be one of the Vice-Presidents has not taken him from the active care and oversight of the work.

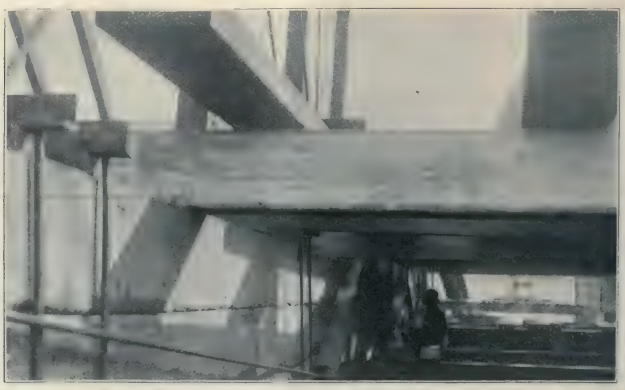
ELECTRIC LOCOMOTIVE FOR HEAVY TRAINS.

When the terminal facilities are completed, all trains within a radius of 25 miles from the Grand Central Station will be electrically moved.

Some Figures that Tell

The extent of the work going on, in the very heart of the great city, with the beautiful cathedral of St. Patrick, in striking contrast, overlooking the busy yards, is difficult to appreciate. Not from every point can even the present extent of trackage be guessed. Within the yards, with the rush and life of the city going on all about, and with the hundreds of trains and thousands of passengers passing through the midst of the engineers and an array of officials, will, as at present planned, present interesting features. In this cramped and congested city, the dominating note of the structure will be spaciousness. In the midst of towering buildings, it will rise to a comparatively trifling height. It is to be a structure of arched and monumental effect, such as one would expect to see, not in New York but in some foreign capital.

To gain the first requisite for spacious-



"Even the temporary is massive."

work, the excavation covers more than twice the amount excavated in the original construction of the Hudson River Railroad, it being necessary to tear up more than a million and a-half cubic yards, more than half of it being solid rock. There is to be a million square feet of concrete paving. There are to be seven miles of four-way electric ducts; there are to be twenty miles of track; there are to be turntables, transfer-tables, and a bewildering maze of interlocking and signaling devices. There will be 30,000 tons of structural steel — more than enough for the building of two modern battleships. Within the new railroad station there will be a fully equipped postoffice, for the handling of the enormous masses of mail which enter and leave there.

The New Terminal Building

The new terminal building, the work of four architects, aided by a corps of

ness of effect, the station will be set back 40 feet from the street line in front, and 70 feet on one side, thus giving a clear, open space of 140 feet on Forty-second Street and of 130 feet on Vanderbilt Avenue.

The main entrance is to be through three arches, each 33 feet wide and 60 feet high. The ticket lobby is to be 300 feet long, and nearly 100 feet wide. The concourse is to be the largest in the world —470 feet long, 160 feet wide, and 150 feet high. The platforms beside the tracks will be 15 to 29 feet in width. There are to be a great number of elevators and stairways, wide exits, and spacious entrance-ways.

Value of Specialization

In connection with the adoption of the plans for the new station there is an interesting story:

There have been four men engaged, with the advice and co-operation of rail-

way officials and engineers as to specific needs, in bringing all the plans to perfection—a firm of two architects from St. Paul, far away though it is, and a firm of two architects of New York. And these architects work together, in friendly concert.

But how did it come that these St. Paul men are working with those of New York on a New York railroad proposition? The answer shows the value of specialization, and also that one should never despair of winning success at points distant from home.

Mr. Charles A. Reed and Mr. Allen H. Stem, the first from Rochester and the second from Indianapolis, went to Minnesota about twenty-five years ago, and, after working individually for a time, as architects, formed a partnership in 1890, in St. Paul. From the first, the firm set itself to make a specialty in one certain line, that of architectural railroad work; and, as the years went by, their reputation increased. Not only in the vicinity of their own city, but at points far distant, they became known. The Union Station at Seattle is their work, and so are other structures throughout the West. But, fortunately for their future, their ambition stretched to the eastward as well. They managed to attract the attention of the New York Central, and here and there along the line a station of their building was put up. Through this tentative opening came their greatest success. When the New York Central desired plans for its new station in New York City, it quietly requested a few architects to submit ideas. Reed and Stem were among the few chosen ones; and such attractive plans did they send in that it was decided to ask them to come to New York to open offices and to superintend the putting of their plans into execution. That was a change indeed! At the same time, the plans of two of the New York architects were found to contain a great deal that was favorable; and, with a broadness which marks this entire work as so unique, the four architects are working together, under combined plans, each helping the others, and all influenced and actuated by the representations of the practical railway heads as to the needs of the traffic.

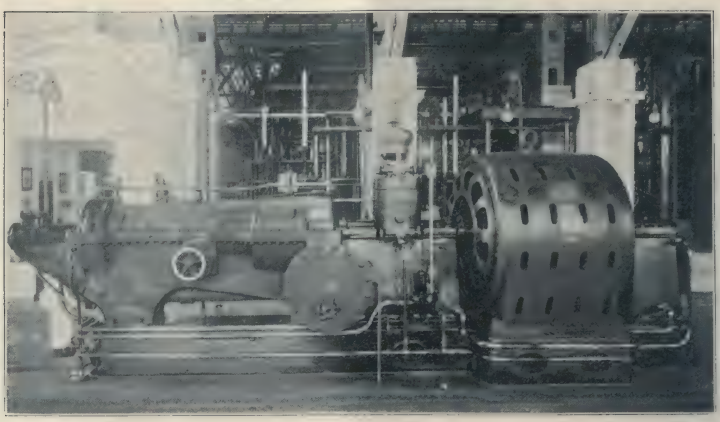
Mr. Reed is a graduate of the Massachusetts Institute of Technology. Mr. Stem, on the other hand, never took a technical course, but he studied architecture broadly, from the standpoint of art as well as utilitarianism, and possesses one of the finest libraries in the United States of books relating to his profession. The firm thus exhibits the advantages of high technical training; and at the same time points out to the young man to whom attendance on college courses has been denied, that it is possible for him to achieve a brilliant success without it if he will take advantage of every educational aid within his reach.

There are situations in which that much-worn phrase, "Captains of Industry," well applies. Here, in these busy yards, is such a situation, where a regiment of a thousand is every day at work; where, indeed, the passengers in the trains find toilers not only to right of them and to left of them and in front of them, but above them and below them as well, and where ten locomotives and almost two hundred cars are used for the new work—in yards already covered with the ceaseless movement of passenger and express traffic.

Within the short period of five years, the entire work is to be completed; it is possible that it may be accomplished in not much more than three.

The speed with which enormous tasks are accomplished is one of the chief wonders of these modern days. In the past, when speed was thought of, the fancy had to rely upon the pronouncing of a magic word or the rubbing of a magic lamp. The magic lamp of the Twentieth Century is fed with money, and the magic word is only a plain "Go ahead." And with modern Captains of Industry peace hath her victories no less pronounced than war.

A 600-HORSE-POWER TURBINE DIRECT-CONNECTED TO ELECTRIC GENERATOR.
Westinghouse-Parsons type.—Broadside view.



The Steam Turbine

Its Development, Possibilities, and Relative Advantages as Compared with the Reciprocating Engine

By DAY ALLEN WILLEY

LESS than ten years ago, the turbine system of developing power was practically unknown to the general public, for it was not until 1897 that the remarkable speed obtained by a turbine-driven steamship attracted attention to its possibilities as an improvement on the ordinary marine engine. It is true that for several years previous a set of turbines had been in service, generating electric current for lighting purposes at Newcastle-on-the-Tyne, England; but this installation was regarded more as an experiment than as a practical application, the four turbines aggregating only 400 horse-power in all. It may be said here, however, that this little plant has afforded a remarkable proof of the efficiency and durability of such mechanism, as it has been almost continuously in service since 1889 at a minimum expense for repairs.

Marine Field First Entered

The fact that the turbine attained a speed of nearly 35 knots an hour, aroused the attention of marine engineers especially to what might be accomplished; and possibly more has been heard of the turbine in connection with shipbuilding than in any other respect, although, as the figures show, its use is becoming very extensive in other ways.

It is perhaps unnecessary to say that, following the design of the Allan Line to construct a vessel for ocean service propelled by turbines exclusively, came the announcement that the Cunard Company would add to its fleet two turbine-driven ships calculated to develop at least 25 knots an hour, and representing fully 60,000 horse-power each. The *Victorian*, which is now in service between Glasgow and Canadian ports, has, it is understood, borne out the claims of her builders that her engines would give entire satisfaction. They are of the Parsons design, five in all being utilized—three for forward propulsion, and two for reversing the ship. She is equipped with three screws, which give a speed of 17 knots an hour, as the vessel was de-

signed more for capacity than for speed.

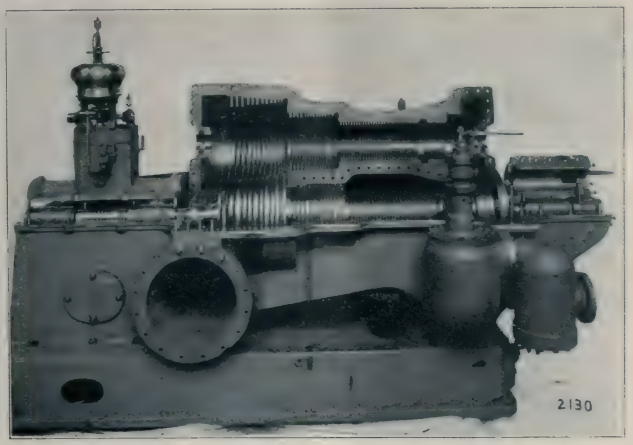
Various Applications

With the success attained in the application of the turbine to marine service, it is not strange that it should have been exhaustively tested in other ways. As a result, the turbine is now being utilized for such purposes as generating electrical current for power and light, for driving power tools and other equipment of the modern machine shop, for operating blowers in connection with woodworking plants, for pumping water in mining and other operations, and for generating electric current for lighting railway trains, power being secured indirectly from the steam locomotive. Some idea of the utility of the turbine can be gained when it is stated that a conservative estimate shows nearly if not quite 1,000,000 horse-power at present in actual use or under construction to be completed in the near future. Over 100,000 horse-power has been installed in vessels of various kinds within the last two years; and contracts for constructing mechanism representing 200,000 horse-power in all, have been taken for the manufacture of Westinghouse-Parsons turbo-generators in the United States and Canada.

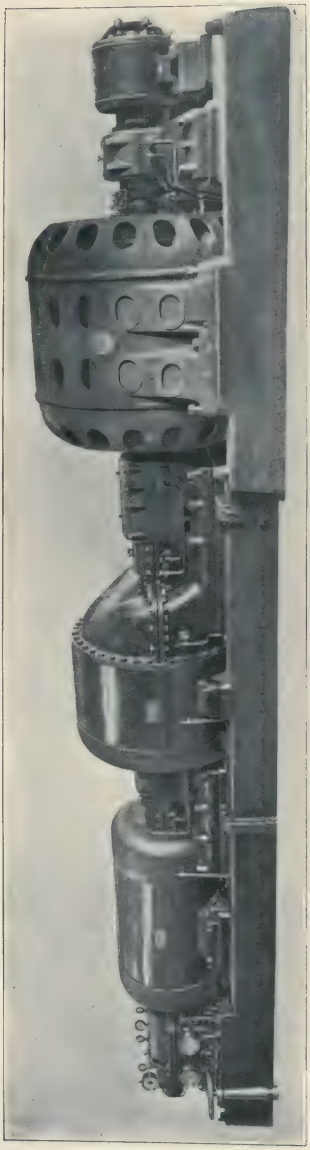
The demand for this equipment has led to the construction of some units of great capacity. For example, the power house of the underground railway system of London contains several steam turbines, which represent 7,000 horse-power each. The New York elevated and subway system is to have a turbo-generator representing no less than 8,000 horse-power; while the main power station of the Philadelphia Rapid Transit Company is to have three of 8,000 horse-power each. American manufacturers are even sending turbines to Japan for various applications of power.

Mechanical Details

The types of turbine which are principally utilized in the United States, are illustrated by the accompanying photographs, which include one developing 600 horse-power. The turbine consists essentially of a number of impulse wheels mounted side by side upon a revolving spindle, and surrounded by a casing, or cylinder, which constrains the working steam. On the adjacent surfaces of both, are rows of radial blades, or vanes, between which the steam passes, each row on the surface of the spindle alternating with a similar row on the wall of the cylinder, the latter serving to give direction to the expanding steam, while the former immediately abstracts velocity thus formed, energy being delivered to



SAME TURBINE OPENED.
Showing interior of steam chamber and formation of vanes.



A 2,250-H. P. TURBINE DESIGNED FOR MARINE AND OTHER SERVICE.
Hamilton Holzwarth Type,—Direct-Connected to 1,000-K. W. Generator.

the vanes by both impulse and reaction. Steam enters at the smaller end of the turbine, expanding parallel to the shaft, its volume gradually increasing and its pressures and temperature decreasing, until, finally, condenser conditions are reached. To accommodate the increase in volume, vanes of increasing length are used; and, when a mechanical limit is reached, the diameter of the spindle is abruptly increased. No similarity, therefore, exists between the three drums of the turbine and the three expansion stages of a triple-expansion engine, as is frequently believed. A much higher degree of expansion of steam is possible in a turbine, and, therefore, a greater economy. The design is very simple, there being no distribution valves, pistons, or connecting rods. To compensate for the small amount of thrust along the axis of the turbine, due to the pressure of the steam against the blades, three revolving balancing pistons are provided at the opposite end of the rotor. These rotate without friction in their casings, and automatically maintain a perfectly balanced condition along the shaft under all conditions of load and pressure.

The bearings of the turbine and generator are oil-cushioned in order that they may be sufficiently flexible to absorb any slight vibrations occurring when the rotor is passing its critical speed—changing from its geometric to its gravity axis. These bearings consist of a set of loosely fitting bronze sleeves surrounding the shaft and supported by oiled films. They are constantly flushed with oil from a reservoir supplied by a small plunger pump which is operated from the governor shaft.

The steam is controlled by a sensitive centrifugal governor, geared from the turbine shaft and adjustable while running, thus enabling alternating-current generators to be successfully operated in multiple. Steam is admitted in short puffs, the governor varying the period of admission. The automatic adaptability of the turbine to heavy overloads is effected with the aid of a by-pass in the cylinder, through which high-pressure steam may be admitted directly to the second, or middle, drum of blades—the internal pressure at this point, and therefore the capacity of the engine, be-

ing increased. On a decreasing speed, resulting from heavy overloads, the governor opens this by-pass; and, if the speed continues to diminish, the governor shuts off the steam entirely, thus preventing any damage to the turbine or generator.

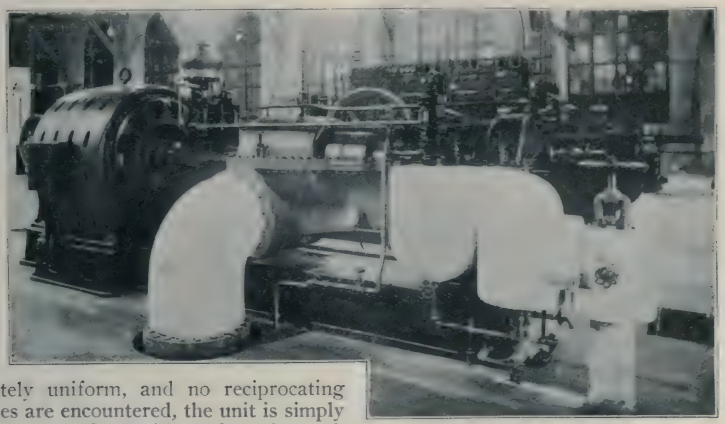
The foundation for the turbine unit consists simply of ten-inch steel beams spanning a condensing pit. As the velocity of rotation of the turbine is absolutely uniform, and no reciprocating forces are encountered, the unit is simply set upon the floor without fastenings. A complete condensing outfit is installed in the pit, consisting of a surface condenser having 1,500 square feet of cooling surface, a rotating dry vacuum pump 6 by 10 by 10 inches, providing a constant vacuum of 25½ inches. The condensed steam from the turbine flows into a hot well at the bottom of the condenser, from which it is pumped to the boiler.

The Turbo-Generator

When it forms a portion of an electrical generating unit, the turbine is usually direct-connected to the generator, as is frequently the case where other forms of steam or hydraulic power are brought into service. The turbine shown in the accompanying illustration was connected with a generator having a rated capacity of 400 kilowatts, and was capable of delivering a three-phase alternating current of 440 volts, the number of alternations being 7,200. As an indication of the service provided by this type of turbine, it may be said that it actually revolved so rapidly that the peripheral distance it traveled, if determined by linear measure, would amount to over 7,000 miles every 24 hours.

The Turbine Pump

The application of the turbine to the pumping of water, is also very interesting. The design illustrated represents 58 brake horse-power, and is of the De Laval type, having a steam pressure of

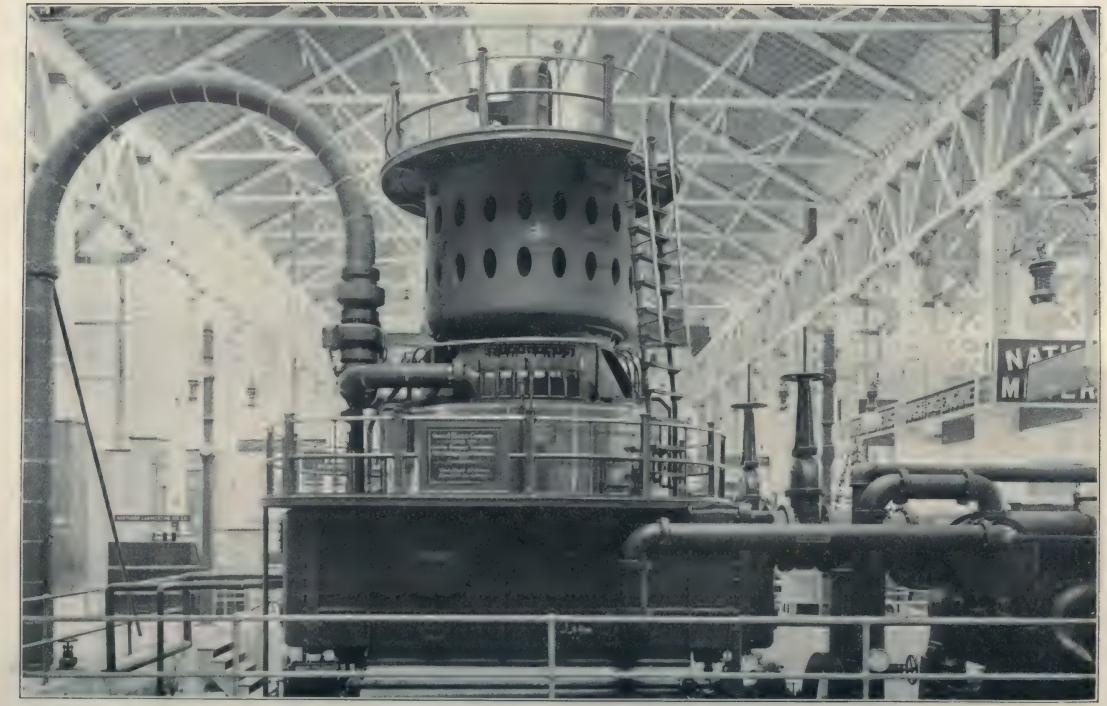


VIEW OF TURBINE AND GENERATOR. Taken while in operation.

180 pounds. It has actually pumped 250 gallons per minute, representing a total lift of no less than 700 feet. The turbine pump, however, has been manufactured in sizes as large as 300 horse-power, with a capacity of 2,000 gallons per minute and 500 feet head. These turbines are operated both at low pressure and at high pressure, the low-pressure turbine being of the centrifugal pattern, having turbine and pump mounted on the same base. The high-pressure pattern works on the same principle as the low-pressure pump, and is being placed in service for fire protection, for operating hydraulic elevators, and in municipal waterworks.

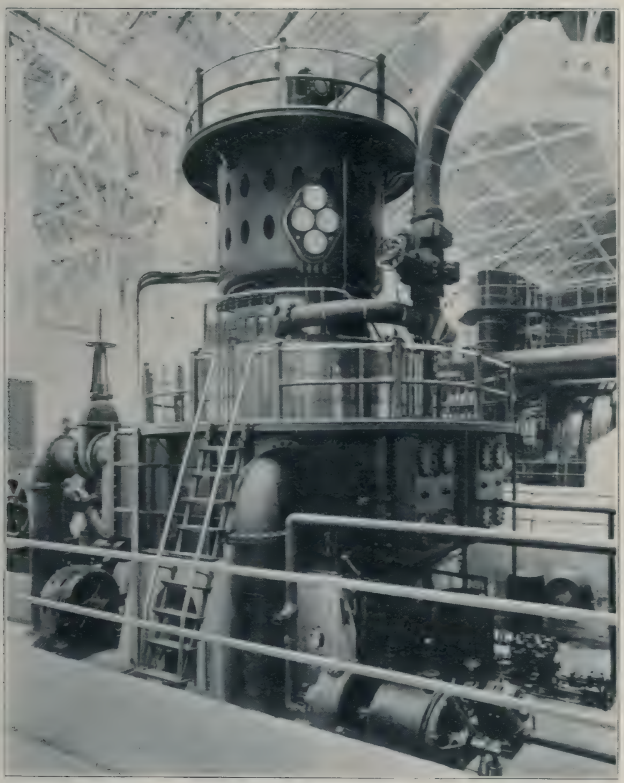
The Machine Shop Turbine

As already stated, the turbine is now taking its place in the shop for driving power tools of various kinds. In most instances, power is communicated by



BROADSIDE VIEW OF UPRIGHT TURBINE OF CURTIS TYPE, CONNECTED TO GENERATOR OF 5,000-K.W. CAPACITY.

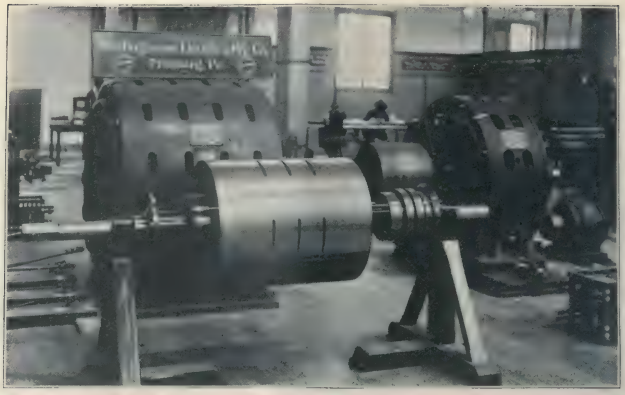
means of a rope or belt drive: and the machine shop turbine is now manufactured in sizes developing as high as 300 horse-power, with a steam pressure varying from 60 pounds to 300 pounds. The small amount of space required for the installation of the turbine as compared with other forms of steam power, has caused it frequently to be preferred by steam users where floor space is limited; but it can be employed in vertical as well as horizontal designs.



THREE-QUARTERS VIEW OF THE SAME MECHANISM AND ITS CONNECTIONS.

The Vertical Turbine

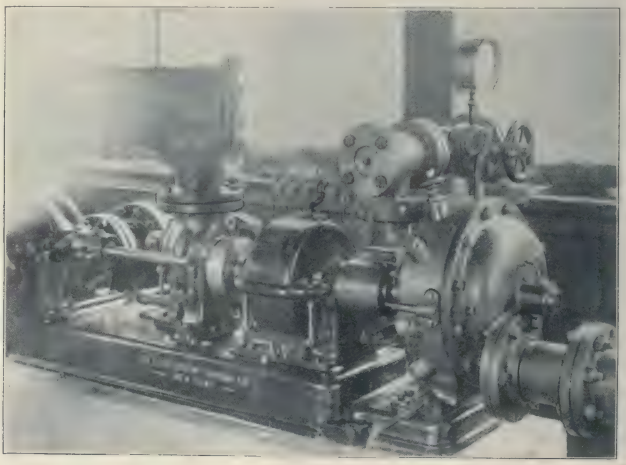
The accompanying illustration gives an idea of the compactness of the vertical turbine, the one shown being connected to an electric generator representing 5,000 kilowatts. This is of the Curtis design, which has found favor in the equipment of street-railway power stations, in plants for electric lighting, and for other uses in large cities. In this design a moderate rotative speed is permitted, as the turbine is divided into stages each of which contains one, two, or more revolving buckets supplied with steam from a set of expansion nozzles. Consequently the nozzle velocity in each stage is reduced. Under this arrangement, the energy of the moving steam



DETAIL VIEW OF REVOLVING FIELD AND ARMATURE OF TURBO-GENERATOR.

is effectively given up to the revolving part. The division of pressure between the stages is so arranged as to utilize the largest possible proportion of the energy of expansion.

By constructing these turbines in vertical form, weight on cylindrical bearings is avoided, as well as any tendency toward shaft deflection. In operating machines of the vertical type, the weight of the revolving portion is supported on a step-bearing placed at the end of the vertical shaft. This consists of two cylindrical cast-iron plates bearing upon each other, with a central recess to receive the lubricating fluid, which is forced in by steam or electrically-driven pumps with a pressure sufficient to sustain the weight of the revolving part. It is apparent that the entire weight of the machine is thus carried on a film of lubricating fluid, and that there is no appreciable friction. When the flow of liquid is interrupted, the bearing is slow-



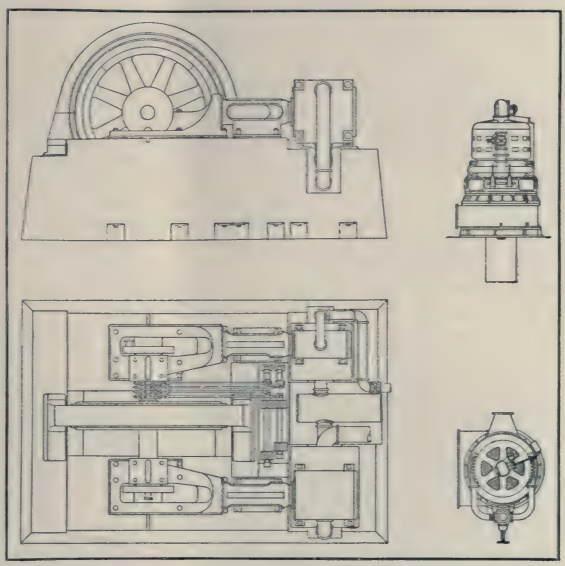
TURBINE-OPERATED PUMP, USED FOR MINING AND OTHER PURPOSES.

Representing 58 brake horse-power.

ly worn away; but experience has shown that interruptions in the flow seldom cause any deterioration which prevents the continuance of the machine in service after the flow is re-established. The tendency of the bearing in such cases is to wear itself to a new surface so that it operates normally.

It has been found that the vertical turbine can also be operated without loss of efficiency, even when subjected to a high overload. One reason for this advantage is that it is readily governed by changing the number of nozzle-sections in flow, and therefore can be regulated to the service required. The speed when operating with a variable load, is controlled by the automatic opening and closing of the original admission nozzle-sections, the number of nozzle-sections corresponding to the load always being kept in flow. A centrifugal governor attached to the top of the shaft imparts motion to levers, which in turn work the valve mechanism. There are a number of valves, each communicating with a single nozzle-section, or, in some cases, two or more nozzle-sections. These valves are connected to long pistons, by which the valve can be opened or closed by steam. The motion of each of these pistons is controlled by a small pilot valve, which is worked by the governor mechanism. The movement of the governor mechanism actuates the pilot valves successively, and the main valves are opened or closed by the steam.

For marine service, as well as for the ordinary power station, various forms of turbine have been designed. One of these, illustrated on page 678, which was shown at the World's Fair, attracted much attention on account of its size. It is of the Hamilton-Holzwarth type, and is intended to develop 2,250 horse-power, although the turbo-generator unit of which it forms a part is rated at but 1,000 kilowatts. The turbine proper weighs 43 tons; and the entire unit, 82½ tons, requiring a supply averaging 20,000 pounds of steam per hour when in service with full load.



COMPARATIVE SPACE OCCUPIED BY 1,500-K. W. CORLISS ENGINE AND 1,500 K. W. CURTIS TURBINE.

Reference has already been made to the area of floor space required for the turbine as compared with other forms of steam motors. The space needed for the former is actually so small in proportion, that it seems almost incredible that from a turbine an amount of horse-power can be obtained which will be equal to that secured, for example, from a reciprocating engine which occupies possibly ten times as much room in the power station.

Industrial Value of Small Streams

Possible Recovery of Enormous Energy Now Wasted, and Its Application to Agricultural and Industrial Uses

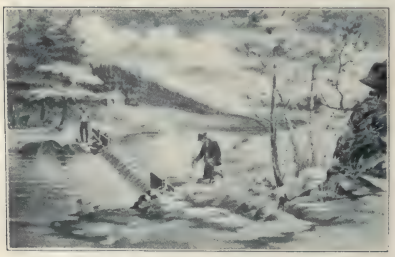
By GEORGE ETHELBERT WALSH

WHEN our coal fields are exhausted of their stored carbon, science will convert water into light and heat, and the sun's rays into power; but in the process of harnessing tides, wind, and light rays, we are coming back to the simple methods of the ancients in their effort to make available the surrounding agencies of nature.

It may be said that nearly all permanently useful progress is toward simplicity; but the human mind is so constituted that it likes to wander afield, and reaches results oftentimes by the most indirect route.

The Steam Turbine

For upward of three centuries now, the steam engine has been passing through an evolutionary process which has refined and complicated it to such a degree that only a specialist in thermodynamics can fully comprehend all the multitudinous parts. But, just as the involved reciprocating steam engine has reached a point of development at which it appears doubtful to the minds of inventors that further improvements can be made, the world is startled by the announcement that the steam turbine is the engine of the present and the future, and that the refined and perfected reciprocating engine is foredoomed to final abandonment. The steam turbine becomes the established engine of the future because of its simplicity. It is a return to a primitive type. At first glance, all the elaborate technical literature and experiments built up around the steam engine appear wasted; but all knowledge is valuable, and the human efforts put forth to perfect the compound and reciprocating steam engines cannot be counted as useless. They all have an important bearing on the new models of an old type of power producer.



MEASURING WATER FLOW BY MEANS OF WEIR.

Illustrations by courtesy of Dayton Globe Iron Works Company, Risdon-Alcott Turbine Company, and S. Morgan Smith Company.

The modern steam turbine, in principle, at least, is practically a combination of Branca's wheel and Hero's æolipile. Branca invented his steam wheel device in 1629; and Hero of Alexandria, his æolipile about 200 B. C. From these crude inventions, the steam turbine has suddenly developed into the commercial power-producer of to-day. Whether for driving the huge machinery of ocean steamers, or for generating electricity to operate street railways, or to light city streets and homes, the steam turbine seems destined to prove the most popular because the most simple and economical of steam engines.

The Gas Turbine

The problem of perfecting the gas turbine promises further advantages with this simple form of power-producer. If a continuous combustion of gas under pressure can be obtained, we shall come one step nearer to the goal of direct conversion of the energy of fuel into electrical energy. The gas turbine will then possess the great advantage of conduct-

CONDUCTING WATER FROM STREAM TO TURBINES BY LONG PIPE.

ing the stored energy of carbon directly to the prime mover, practically eliminating the boiler and the necessity of a water supply.

The Turbine Water Wheel and the Windmill

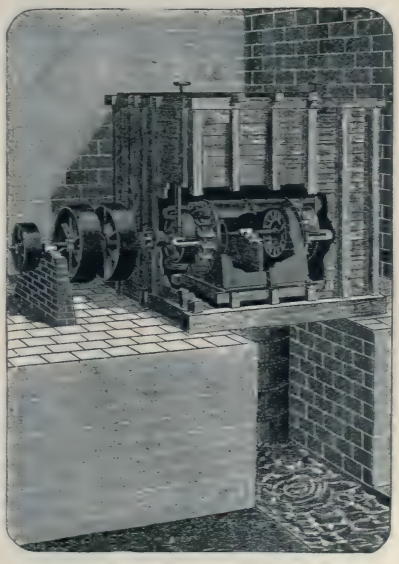
In harnessing the tides and currents of rivers and streams, the turbine wheel follows the same general principle that is being so elaborately sought after in the gas turbine. A return to the water-wheel principle is characteristic of the century. Just when our picturesque water-wheel mills are falling apart through neglect, the turbine wheel of a Niagara or a Messina calls a halt. The windmills have also fallen into decay along our New England streams; but in the new West they are springing up like mushrooms to irrigate arid regions for agriculture. They pump the water from underground reservoirs, and make the very desert blossom as a garden. The harnessing of them to electrical generators to do work on farms, adds further to their usefulness. The hot, dry winds of the prairie districts, which have proved a bane to the thousands of farm holders, are suddenly converted into blessings. With windmills for irrigating land, and for supplying farms with electrical power to operate machinery, the new farmer will become independent of weather conditions, and increase his products tenfold. The direct conversion of wind power into electrical energy, it is true, is still in its infancy; but its successful operation even on a small scale promises to inaugurate an era of agricultural changes that as yet can only faintly be measured.

The Solar Motor

On the Pacific coast, where the sun's rays are hot and constant throughout the greater part of the year, and down in the arid regions of New Mexico, where the heat of summer is almost unbearable, the solar motor works with equal promise of great revolutionary developments. By concentrating the rays of the sun upon a focal point—which is the boiler of the new type of motor—metal can be fused within a short time, and water boiled within an hour after sunrise. The energy of the sun's rays, converted directly into steam power, performs the work of man without friction or trouble. With automatic regularity it grinds corn, threshes wheat, or runs a dynamo for electrical transmission. This form of solar motor, in hot climates, insures for those regions a power that is as abundant and widespread as the light of the sun itself. It is as free and as widely distributed as the air we breathe.

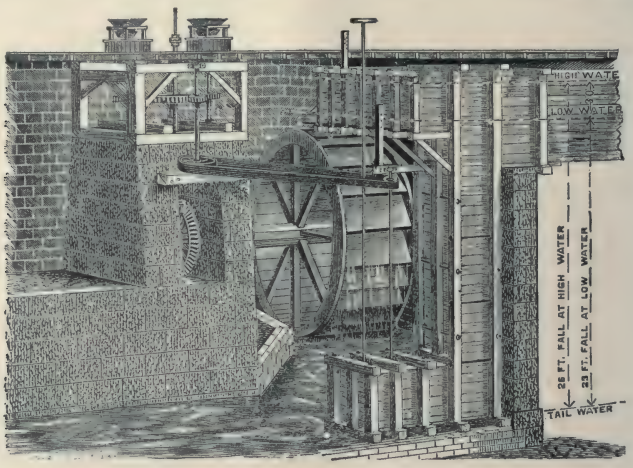
Stored Energy of Streams

The distribution of water, fortunately, is almost as general as that of air and sunlight: and its employment for produc-



FIRST HORIZONTAL-WHEEL SETTING USED IN THE UNITED STATES.
Designed by T. H. Risdon, Mount Holly, N. J.

ing power is as old as man's effort to reduce his toil by mechanical contrivances. The ancient water-wheel mills were something more than picturesque landscape objects to please the eye of the artist. Located on both the large and the small streams of water, they furnished mechanical power for grinding the corn and wheat of the early settlers, and later turned the circular saws of lumber mills and the machinery for light manufacturing. The water turbines of the New England cotton mills established an industry in the oldest section of the country that has not been crowded out of existence by modern applications of steam and electric power.

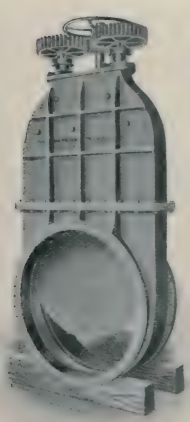


TURBINE AND OVERSHOT WHEEL.

In its early form, however, the water wheel or turbine has been steadily losing ground. It involves a waste of energy that cannot be overlooked in this age of progress and development. The ideal conversion of the power of a stream into electrical energy for long- or short-distance transmission, utilizes the full value of the current, and transforms one of the most abundant of elements into a working agency for man.

The harnessing of Niagara appeals to the imagination as no similar work on a smaller stream could possibly do; but in the aggregate, the hydraulic power of the thousands of small rivers, streams, and brooks represents greater available energy than that drawn from any half-dozen Niagaras. The wide distribution of American rivers seems like the wise dispensation of a Providence who foresaw the coming of an age when their value would be appreciated. With our coal mines exhausted, the streams which flow so gently and smoothly toward the sea would prevent any fuel famine. Heat, light, and power are locked up in the smallest of brooks meandering through flower-decked meadow or swamp. The rippling rivulet that tumbles so gracefully and noisily from rock to rock, and finally loses itself in the turgid bosom of the broader river of the lowlands, is rich in possibilities for the future, containing a potential value that is often overlooked. The muddy ditch that drains the lowlands, and slowly finds its way to some creek or brook, represents a value that may be estimated in any number of horse-power of working energy, when properly harnessed. And even the bubbling spring that furnishes a cool drink to the thirsty, represents a small power plant which may be turned into great usefulness for man's purposes.

The hydraulic possibilities of a brook or stream appear too small and insignificant to most of us; and little thought of developing these sources of energy has



FLUME VALVE FOR REGULATING FLOW OF WATER TO TURBINE.

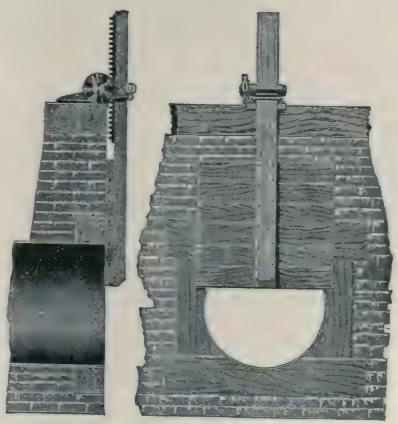
occurred to man in the past. It is only since practical electrical engineering has reached a stage of development which makes every stream of water teem with potential value, that serious consideration has been given to the small water supplies. Along thousands of unfrequented streams to-day, electrical science could build up industrial centers, or establish local power plants to operate farming machinery, to light houses and streets, and to convert the wilderness into fruitful fields and gardens. Through hundreds of farms, small watercourses run which possess more potential value than the soil that has for so many decades been laboriously cultivated.

Agricultural Applications

A farm with ten or fifteen head of working horses is considered a good-sized place, according to Eastern standards of agricultural measurement; and it would represent several hundred acres of tillable soil. But a single watercourse with moderate flow and velocity contains a potential energy of great value for doing the farm work. During the seasons of the year when this flow would be increased, the horse-power available would rapidly mount up to nearly double; or, if storage reservoirs were constructed to hold the supply for uniform use the year round, a further increase of available power could certainly be depended upon.

The average American stream finds its source either in the foothills of mountains, or on some high elevation where a considerable watershed is formed. The drainage of a large tract of land by the stream makes its flow very irregular. In the spring and winter seasons, the stream is swollen to such unusual proportions that it overflows its banks and inundates the surrounding country; or if confined in a narrow bed by high, rocky sides, it forms a violent torrent which is liable to wash away everything that obstructs it. A violent, rushing, turbulent stream six months in the year, it becomes in the summer season a mild, apathetic watercourse that almost stagnates in its bed, drying up finally in places so that only a tiny rivulet flows down its channel. This unreliability of the streams has been a source of anxiety and great expense to manufacturers for decades, and the annual floods and washouts of mill property cause losses of millions of dollars.

The streams that would yield from 500 horse-power down to 50 horse-power are numerous, and are so well distributed that few parts of the country can be said to be minus great possibilities in this direction. With a small stream of 25 cubic feet per second as the minimum flow, and a working head of ten feet, the amount of power that could be developed with



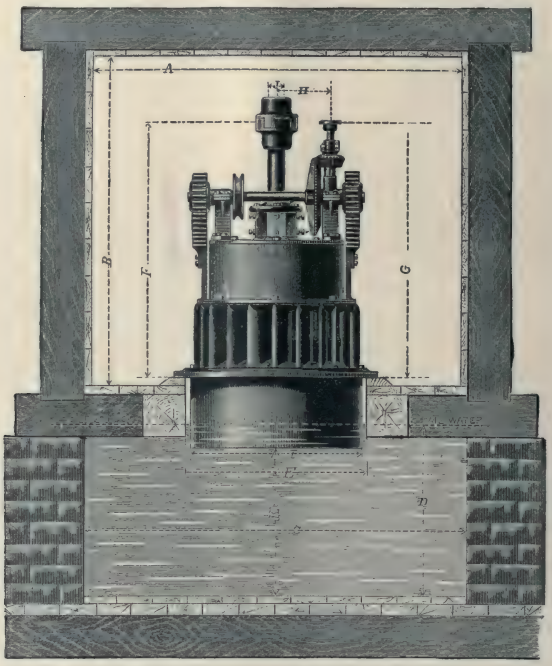
SECTIONAL AND FRONT VIEW OF WINCH-WHEEL AND LEVER HOIST.

a first-class modern turbine would be about 55 horse-power. This would develop some 35 kilowatts to be sold or used for different electrical purposes.

A Storage Pond

To increase the capacity of the plant by constructing storage reservoirs, an ordinary stream with a minimum flow of 25 cubic feet per second for 12 working hours per day could be doubled in its output by deepening a twenty-five acre pond one foot and storing there about one million cubic feet of water. Such a reservoir is not difficult or expensive to make; and in the case of an ordinary stream, it would fill up at night, while in the daytime the increased use of the current would scarcely draw off the extra foot of water. A storage pond, used either for increasing the capacity of the plant in the twelve hours of each working day, or for storing water for the dry season, enables the owner to make full use of a stream's value. In the winter season, sufficient water is wasted, even by the ordinary small stream or brook, to run several plants all through the summer season.

The value of a 50-horse-power plant on small streams, is not appreciated by the average person. Such a plant could generate enough electricity to light a small village of 2,000 to 3,000 inhabitants, and still have a small surplus for the daytime to operate a grist mill or small manufacturing plant. If the power could be run continuously night and day, which in the wet season would be possible, the town or village could be amply provided with electric lights, and a considerable-sized manufacturing plant operated for at least nine months in the year. Thus, from an ordinary stream, there would be developed power, light, and heat that would represent many thousands of tons of coal each year. The



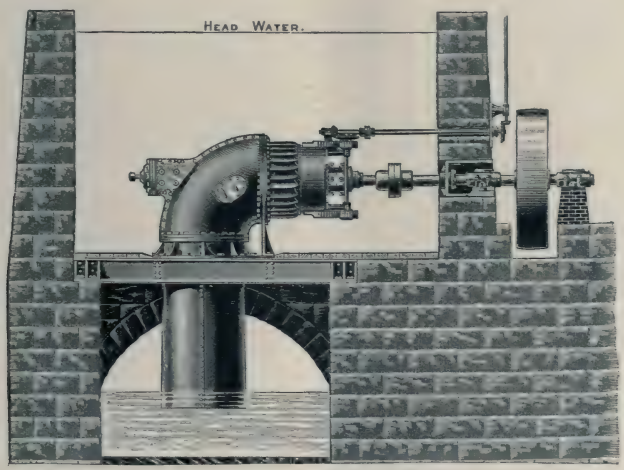
TURBINE INSTALLED IN WOODEN FLUME.

saving to the village itself would be enormous. The thousands of dollars paid out for fuel would go to improve local property, and in the end would be partly distributed in the form of dividends among the stockholders of the electric plant.

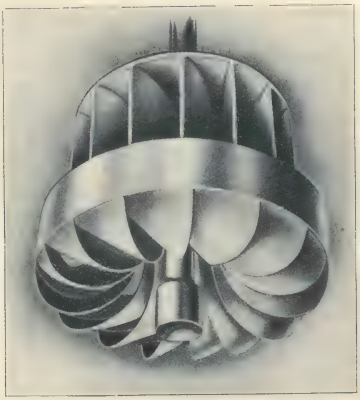
A 50-horse-power plant could operate during nine months in the year a street railway five miles in length, with ordinary surface cars running every ten minutes past a given point. If the car service stopped at night, there would still be sufficient power left to furnish the village with electric lights. The operation of a railway service of this character would be amply sufficient to accommodate the ordinary traffic of a village of the size mentioned, with suburbs spread over a radius of several miles in either direction. The value of such railway service to small villages, especially where there are two or more situated close together, is so great that many owe their sudden growth and doubling of population to no other cause. The operation of an electric line, however, where power must be generated entirely from the combustion of coal, is generally too expensive an undertaking for such small towns. With a stream of water flowing idly near a village, the work of harnessing it offers a solution of many a rural problem that to-day appears too involved for unraveling. Transportation facilities are the first essential step in modern progress of any rural town or village. Without adequate electric connections with the nearest railroad, the community situated a few miles back from the station will inevitably stagnate and die of inaction.

Electricity in Farming

A small stream furnishing 50 horse-power throughout the day and night, could, in a strictly farming region, operate two or three large creameries in the daytime, run several modern threshing machines in the harvesting season, furnish light for the barns and homes of the farmers within a radius of five or ten miles, and still have power enough to operate a dozen and one small farm machines, such as corn shellers, root cutters, hay choppers, and bone grinders. With the electric light wires running into the barns of the different farmers, instant power would be on hand at all seasons of the year to do the ordinary hard work that now is performed by man



SINGLE 27-INCH HORIZONTAL-SHAFT TURBINE.
Mounted on cast-iron elbow set in open, stone flume under 26-foot head, developing 175 horse-power. Single wheels cost less per horse-power than double wheels.



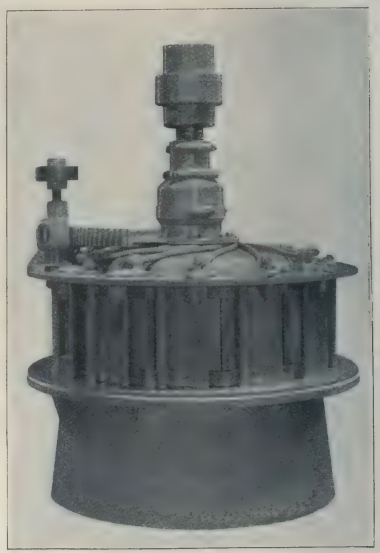
CONTINUOUS CAST RUNNER OF TURBINE OF "NEW AMERICAN" TYPE.

or animal power. Even where the hay and grain are raised on the farm, it costs more to keep and feed a horse than the electricity would amount to per horse-power the year round. There would be a saving of nearly one-half where the stream was harnessed through the co-operation of the several farmers of a region.

A single farm of 400 to 500 acres could be run with a 50-horse-power station with great efficiency, doing away with horses for hauling and operating machinery, and lighting and heating the barns and houses. Such a farm could be equipped with all modern machinery and implements, from the large double-gang electric plows and harrows to small cultivators, corn shellers, threshers, and churns and separators. When all of these different implements were put into operation, there would still be surplus power to sell, especially during the night time, when the ordinary machinery would be quiet. A modern electric farm of this character typifies in a way the farm of the future.

Plant Forcing and Pest Extermination

Agriculture is simplified and stimulated by electricity in many different ways. Electric lights are becoming valuable adjuncts to the greenhouse and forcing frames. The effect of the light rays upon the plants is noteworthy. Some are stimulated in their growth under the influence of the electric arc, so that their period of growth is lessened by several weeks. Other crops are almost doubled in their yield when stimulated by the electric light by night. The electrification of the soil by means of wires running underground, is another fertile field of experiment and practical effort that promises revolutionary results. The same power which stimulates plant growth when moderately applied, also proves destructive to weeds and noxious plants and insects. By charging the wires with a heavy current, and keeping this up for a few hours in the fall or spring of the year before or after the crops are planted, every weed and insect in the soil could be exterminated. In the opinion of leading agriculturists, this method of controlling the weeds and insects will in the future eliminate from the problem two of the greatest sources of loss of the age. Millions of dollars are annually lost through the destructive agencies of insects, and nearly a third as much from the growth of noxious weeds and foreign plants. By controlling these through electrification of the soil, the crops would have an opportunity to multiply as never before.

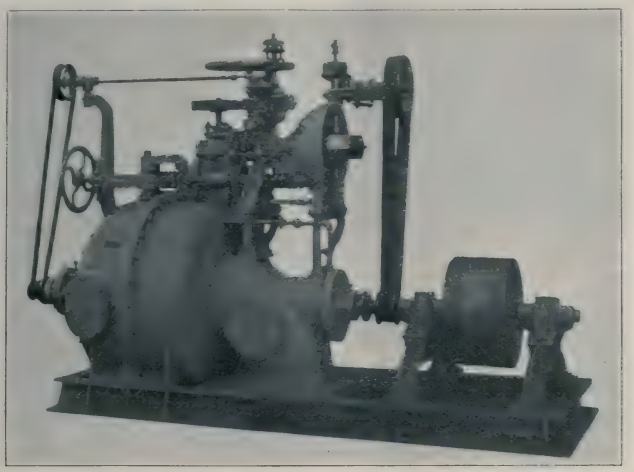


THE "NEW AMERICAN" TURBINE.

The possibilities of small streams of water in changing the physical conditions of the surrounding country, extend to new fields as modern science advances and demonstrates the many-sided value of electricity. If a small stream contains possibilities such as we have described, what must be said of the innumerable larger watercourses that have double and three times the flow? In New England alone there are scores of streams that could furnish several hundred horse-power without elaborate storage engineering; while hundreds of smaller ones can be found that have a capacity of 50 to 100 horse-power.

But still smaller streams than those rated with a 50-horse-power flow could be profitably utilized by modern electrical engineering. These plants could furnish the power for farms and small manufacturing concerns, grist mills and lumber mills, electric lighting and pumping. Even the 10-, 20-, and 30-horse-power stream, whose flow could be regulated the year round by means of storage reservoirs, would prove of the utmost commercial and industrial value to any section of the country.

The measurement of the exact flow of the stream, and its head, with all possible engineering data concerning its draining of surrounding country or watershed, enables modern owners to calculate beforehand the relative value of any waterway. The hydraulic proposition is a simple engineering problem that can be easily ascertained. The development of the power plant then follows well-defined lines. The dam of a small stream requires only a well-ballasted timber crib, with secure foundations and supporting abutments. The cost of such a dam is low, and it lasts for years. The turbine wheel and electrical generator should be suited to the size and flow of the stream, due allowances being made for the danger of overflow and erosion from ice. A single turbine is cheaper; but when the flow is very irregular, two or more wheels minimizes the dangers of breaking or of discontinuance of work through accident.



SMALL HORIZONTAL TURBINE OF "NEW AMERICAN" TYPE.
Designed for La Aurora Jute Mill Company of Mexico, by Dayton Globe Iron Works Company, Dayton, Ohio.

The electrical equipment of a plant, however, is an engineering problem that requires study and experiment for each individual case; and no generalization would give more than an approximate idea of the amount of work or cost involved in developing the stream. The fact that permanent sources of small power are flowing idly at our very doors should prove stimulating enough to turn our minds seriously toward the problem

of availing ourselves of nature's wise bounty. In the next era of electrical development, science will devote itself to the utilization of the numerous small streams rather than to the industrial exploitation of the large ones. The harnessing of Niagara has resulted in the building up of important new groups of industries; but there must be a limit to the use of cheap electrical power along the line of any one stream. The cost of transmission of electrical current beyond a radius of fifty miles is so great that there is a natural limit placed upon the development of a Niagara or a Messina rapid.

On the other hand, our small streams flow through all parts of the country where local power, heat, and light are actual necessities. As long as civilization demands these, the value of streams furnishing the power must tend to increase. The question of harnessing them profitably concerns thousands of those who live in the rural districts, while the future of our village life depends a good deal upon the comforts and luxuries that can be obtained through some such means as those described.

Our American streams are noted for their beauty and scenic surroundings, and they need to be preserved rather than destroyed. By the construction of reservoirs and receiving ponds to store the water for dry seasons, we tend to counteract the evil influences of forest denudation, which has already dried up many a small brook and water course. If utility and beauty can thus work together to accomplish the same purpose, science will score a success greater than any measured simply by dollars and cents. Our watercourses are the most valuable assets that nature has bequeathed to us, and we have just begun to appreciate the inheritance that has for so long lain idly at our feet. Another generation, it may be expected, will work out a change that is but indifferently comprehended to-day.

More

MORE ships there are that sail the ocean wide
Than now thou thinkest or can'st realize.
Who knows when some swift turning of the tide
May bring to thee the one that bears a prize?

More loyal human hearts there are, I wot,
In this old world than we can e'er divine.
How many of those hearts thou knowest not,
May beat in loving sympathy with thine.

More isles are sleeping in the far-off sea
Than have been seen—than men have trodden yet.
In life more beauties are awaiting thee
Than thus far in the journey thou hast met.

—J. Leroy Stockton.

MOUNTS STEPHEN, CATHEDRAL, AND VICTORIA.
View from the Pass between Mounts Daly and Niles, Waputehk Group.

Pioneer Climbing in a New Switzerland

Fascinations and Dangers of Mountain Climbing in the Canadian Rockies and Selkirks

By CHARLES E. FAY
President of the American Alpine Club

IT is almost half a century since alpinism received its first strong impulse through the founding of the famous Alpine Club in London, England. During this period, hundreds of thousands of tourists have been attracted to Switzerland by the descriptions of magnificent scenery or by tales of stirring adventure published to the world by the members of that society, or of others patterned after it in many lands. The scaling of seemingly inaccessible peaks has exercised an unparalleled fascination on serious men endowed with a love of adventure; while delight in the grandest spectacles that Nature can offer has brought as worshipers at these shrines a yet greater number of persons content merely to gaze upon "Alpine majesties" and to leave to others their exploration and conquest.

The Canadian Alps

Meanwhile, upon our own continent, there was lying unknown even to our geographers an alpine world still vaster in area and scarcely less impressive. Though its snow-clad peaks do not rise so high above sea as do those of the European Alps, they tower almost equally high above their valleys, and in an infinite variety of architectural forms. Their glacial features are as marked. In exquisitely beautiful lakes and mighty

MOUNT LEFROY.
First ascended in 1897.—The cliff is probably 3,000 feet sheer, exclusive of the ice-wall at its top, which is nearly 300 feet additional.—The water is Lake Louise.

cataracts, Switzerland is quite outclassed. Only through the influence of agriculture in developing a less severe type of beauty, does the Swiss landscape regain its prestige.

Only a few explorers had traversed the region up to the time when the demand for a transcontinental line across the Dominion of Canada led to the building of the Canadian Pacific Railway. Fortunately, the most available of the many routes surveyed across the Cordilleran belt proved to be the one that passed through the heart of two of its grandest alpine districts. Entering the mountains by a noble portal through which the Bow river comes forth upon the prairies, the railway follows back along its course, passing through rampart after rampart beneath mountains towering 5,000 feet above the track, until, amid the culminating grandeur of the ice-crowned Bow range, it crosses the main watershed of the continent. Now upon the Pacific slope, it makes its way by a yet wilder valley to the Columbia river, here flowing in a northerly direction. The several ranges thus far crossed form the Canadian Rockies, properly so called; those whose scarcely less impressive peaks occupy the great interior island formed by the strange sweep of the Columbia and Kootenay rivers, are the Selkirks. The two groups taken together may for convenience be called the "Canadian Alps."

In the heart of both these regions, almost wholly uninhabited, the necessity of feeding the passing tourists led to the erection of several excellent hotels: places in a new alpine world, at the present time the most accessible—even to Europeans — of the several regions that are alluring into new fields men no

CLIFFS OF "THE BASTION" (10,200 FEET HIGH).
The glacier and a lakelet of Consolation Valley lie at its base.—The remarkable architecture of the peak is characteristic of the friable limestone and quartzite of the Canadian Rockies.

hence the seekers after the grandest in the way of scenery need no longer cross an ocean to enjoy it; and American lovers of the strenuous sport of mountaineering have at hand sojourning longer satisfied with repeating the ascents of grand peaks grown hackneyed. And what a joy the pioneer work of detailed exploration of these wild valleys and soaring summits has been to those

of us who were among the first upon the ground, and whose devotion has brought us with each subsequent summer to scale new peaks and discover new splendors

avansaries with every modern convenience, have been our headquarters for successful assaults upon neighboring giants, or our base of supplies for camp-

EIFFEL PEAK.
Another typical example of rock forms in the Canadian Rockies.

in the way of unsuspected glaciers, sapphire lakes, and waterfalls whose plunge is comparable only with the highest cataracts of the known world! The hotels, which we have seen transformed from railway lunching stations into great car-

ing trips in campaigns against peaks more distant from the haunts of men.

The beautiful hotel at Lake Louise, which, though year by year enlarged, still cannot keep pace with the increase in numbers of those who come to look

upon its matchless panorama, was a little chalet of eight rooms when it furnished the base for our attacks upon the formidable peaks of Lefroy and Victoria, both conquered but a day apart in the summer of 1897. Until that season, no Swiss guide had led parties among these Alps, whose perils, nevertheless, are of the same nature as those which annually prove disastrous to so many more or less careless or ignorant climbers in Switzerland. Possibly we who relied upon knowledge won in years of experience among the widely different difficulties of Appalachian peaks, presumed too far, and unconsciously assumed risks which only a happy fortune prevented from ending in disasters. Better instructed now after several seasons, with our reliable guides, we may admit our temerity in those first years.

LAKE MCARTHUR, IN THE CANADIAN ROCKIES.
This beautiful sheet—its water an exquisite sky-blue tint, lies in a rock basin, 8,000 feet above the sea and almost above vegetation.—The summit on the left is Cathedral Peak. In the background on the right is Mount Odaray.

A Thrilling Moment

What an experience was that of 1894 in a day's ramble about the base of the soaring obelisk of Mount Sir Donald, the so-called "Matterhorn of the Selkirks." Rebuffed by its steep cliffs, we turned in mid-afternoon to scale its lesser neighbor, Eagle Peak. Approaching night found us still below its summit, and face to face with the impossible. To descend as we had come up was our only alternative; but, not intending to return by this face of the mountain, we had not taken measures to mark our way over the narrow shelves and short precipitous declivities. At the very beginning of our descent, in repassing an angle in the cliff we had just now rounded with some difficulty, came a moment of terrible suspense. My only companion, a dear friend of many a mountain ramble East and West, was a man of stout proportions, far heavier than I. More pliant to the demands of the protruding rock,

ON THE SUMMIT OF MOUNT GOODSIR (nearly 12,000 feet high).
First ascended in 1903.—The snow to the left of the footprints is a "cornice" overhanging a precipice nearly 6,000 feet high.

NORTH TOWER OF MOUNT GOODSIR.—MOUNT VAUX (10,000 FEET) IN BACKGROUND.
Peaks of the Ottertail Range West of the Divide.

I had easily passed around its obtrusive angle upon a narrow shelf—yet even this discontinuous at the very turn. My companion stood now at this critical point, with one foot on either side, grasping hand-holes safe yet wide apart. In endeavoring to swing himself past the turning point, the pressure grew serious. To my dismay, I heard him say: "I must let go." Below was a precipice of at least five hundred feet, ending at the glacier. Helpless to assist him by any material aid, I could only say with feigned calmness and encouragement: "Oh, no! you are not going to let go." To my infinite relief, he that moment passed the crucial point and stood beside me again in safety.

Trapped for a Night

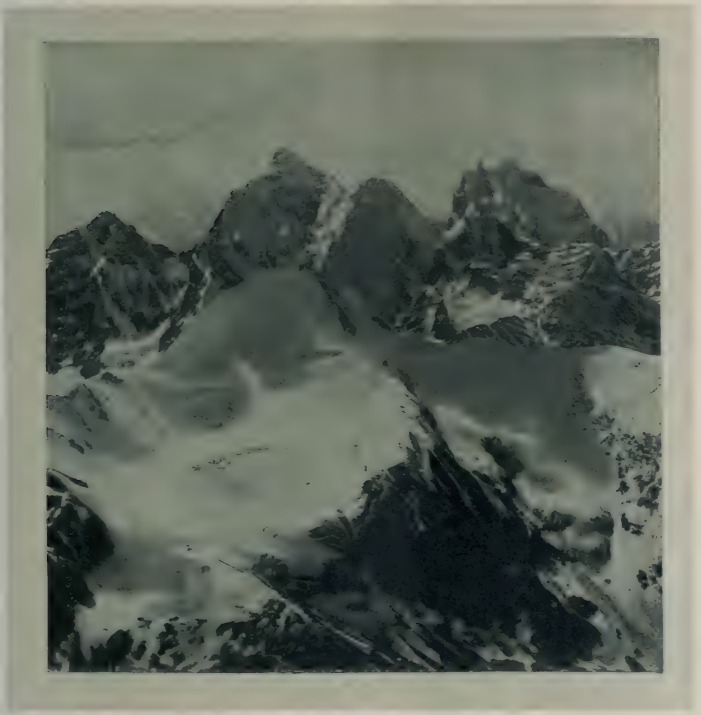
It is a curious fact in psychology that at such moments—when much remains to be done—there is no time to yield to emotions. We had used up considerable of our scant time, and it was growing dusk. Each yard of distance must be covered with caution, hovering, as we were, above an abyss. With all our efforts, darkness overtook us while astride of an angular rock over which we were passing. A night on horseback in this fashion was too little promising! A careful reconnoissance disclosed just below us a shelf some seven feet wide, standing out from a sheer wall that towered above it. Almost as sheer were the hundreds of feet from its margin down to the glacier. A crevice just wide enough to receive us both ran across it from wall to edge. It was safety and comfort compared with our late equestrian situation, and here we passed the night. At the Glacier House, now 3,000 feet below us but invisible (indeed no remotest suggestion of humanity could be seen from our desolate eyrie), we had slept the preceding night under two heavy blankets. Now we had not a wrap of any sort. For food, we had the meager remnants of our day's luncheon, and no water. With kindly charity, my mate made me the sharer of his greater bodily warmth, and I sat holding him close against me like a down pillow. The moon rose soon over the superb pyramid

of Sir Donald just across the glacier, which was flooded with its light. What would have been an oppressive silence, was broken by the dash of distant waterfalls, or the more ominous crash of loosened rocks or masses of ice from the hanging glacier on the great peak opposite. If only we were safe from such assaults, we could make a tolerably comfortable night of it. Indeed, from time to time, my comforter would give forth slumberous tones, wherefore I felt justified in clasping him the more tightly.

But the longest night ends. It does not, however, always compensate for its tedium by yielding to such a sunrise as it was our privilege to witness, when the vast expanses of the Illecillewaet and Asulkan glaciers vied with the fleecy cloud-wreaths in reflecting the rose and lemon tints of breaking day, while a stern multitude of giant peaks took on a momentary flush of kindliness. It was a sight never to be forgotten.

We now turned to finding our way out of the strange trap in which we were taken. Five hours of search—now below, now above—gave us no clew. At length the narrow ledge by which we had come around our arête was revealed within twenty feet of where we had passed the night; and a rapid descent brought us back to the hotel in advance of the rescue party kindly sent out in our behalf.

But with the introduction of expert guides, of whom the railway company brings over six or eight for each season,



MOUNT GOODSIR, CANADIAN ROCKIES (11,671 FEET HIGH).

First ascended by Prof. Fay and party, July 16, 1903.—The highest peak visible from the line of the Canadian Pacific Railway.

such episodes are out of date, as well as those of another sort, in preventing which more experience on the part of our climbers is also a factor. Such a one was that which befell a member of our party in 1897, our Anglo-American combination, the English contingent of which had brought over Peter Sarbach, the first of Alpine guides to visit this region. We had scaled Lefroy, and, in the good Queen's jubilee year, the noble peak of Mount Victoria, and now were assaulting a lofty summit springing from the great Waputehk snow-field. It was the first time its expanses on the eastern side of the Great Divide, which it swathes with its vast blanket of ice, had ever been pressed by human feet. Aiming at Mount Balfour, we had found ourselves instead upon Mount Gordon—so called after the family name of Lord Aberdeen, then Governor-General of Canada. This mountain rises in a long ridge on whose crest the watershed runs northward from the summit first attained. The high dome in which it ends had attracted us as a better station for surveying purposes, and four of our party of nine started for it over the perfectly safe ice that lay between.

MOUNT FAY, CANADIAN ROCKIES (10,637 FEET HIGH).

First ascended by an Englishwoman, July 20, 1904.—Approached from the exquisitely deep blue Moraine Lake, lying in the "Valley of the Ten Peaks," formerly known as "Desolation Valley." These summits generally rise in craggy peaks along a great wall of rock here forming the ridge-pole of the continent. Mount Fay, third in order of height, is the snow-clad peak in the left background.

MOUNT GOODSIR, FROM THE SOUTH.
From the summit, the view northward includes the valley traversed by the Canadian Pacific Railway, lying 8,000 feet below.

A Narrow Escape

Just before reaching the top of the dome, a long crevasse intercepted our course. Its extremity was bridged with snow, perfectly safe to cross for a roped party—which we were not. It would have been the part of wisdom to make the short detour necessary to pass entirely beyond this snow bridge; but, after testing its strength with an ice-axe, it was deemed safe to cross it. The leader lay flat and "swarmed" across it—a motion between a swim and a wriggle. The second followed suit; the third jumped the thinner part; the last, however, whose attention had been diverted, supposed that his predecessor had walked across, and started to do the same. In the very middle, he broke through; but his ice-axe, held horizontally, caught on the surface and supported him. Had he simply clung to it, all would have been well. But, while two of us were seeking to secure a hold upon the straps of his rucksack, by which we could at least have held him indefinitely, our third offered him his ice-axe to grasp. To do so, he relaxed his hold upon his own. The sudden strain upon the other wrested it from the grasp of its holder, and with it our companion instantly vanished from our sight. It was impossible to approach the aperture he had made in the treacherous bridge in order to look down. No sound came from the gulf that had so suddenly swallowed him. Our shouts attracted the attention of the balance of the party, already following us but still nearly half a mile away. With them was Sarbach, with fully two hundred feet of Alpine rope. On they came at full speed, the guide in advance; but every minute seemed an age. A voice was heard—doubtless from one of them. Then another silence, unbroken unless from the beating of our hearts, dismayed at the dreadful consequences of our incaution. Again the voice! and to our infinite relief, came the discovery that it arose from beneath, and had in it a touch of vexation: "Can you not get me out soon? It's awfully cold and nasty down here." No earthly symphony could have sounded sweeter. Our companion was alive, and to our amazement, unhurt! Absence of breath, suddenly lost in the shock as he became jammed in the ice where the two walls of ice drew together, had kept him so long silent.

The others of our party were soon assembled at the crevasse. A friendly emulation as to who should be lowered to

TAKAKKAW FALL, (NEARLY 1,200 FEET HIGH).
View taken on a hot day, when a vast volume of water is descending from the melting ice of an extensive glacier. — Fall discovered in 1897. — Its sources and upper end first visited by Prof. Fay and party in 1903.

the rescue, ended in our deferring to Dr. J. Norman Collie, of London, by all means the most able alpinist of our number. In his recent interesting volume, "Climbs and Exploration in the Canadian Rockies," Doctor Collie tells the remainder of the story as follows:

LAKE MCARTHUR, LOOKING TOWARD THE BOW RANGE.
A considerable glacier enters at its upper end, visible through the intensely blue water. Fragments break off and float as miniature icebergs. Prof. Fay and party found this lake frozen solidly over, on July 27, 1902.—The peak at the right of the picture is that of Mount Biddle, 10,000 feet high.

"It was not until I had descended sixty feet . . . that I at last became tightly wedged between the two walls of the crevasse, and was absolutely incapable of moving my body. My feet were close to Thompson's, but his head was . . . about three feet lower than his heels. Face downwards, and covered with fallen snow, he could not see me. But, after he had explained that it was entirely his own fault that he was there, I told him we would have him out in no time. At the moment, I must say, I hardly expected to accomplish anything. For, jammed between the slippery walls of ice, and only able to move my arms, cudgel my brains as I would, I could not think what was to be done. I shouted for another rope. . . . I managed to throw one end of it to Thompson's left hand. . . . But when pulled, it merely dragged out of it. Then, with some difficulty, I managed to tie a noose on the rope by putting both my hands above my head. With this, I lassoed that poor, pathetic arm, which was the only part that could be seen. Then came the tug of war. If he refused to move, I could do nothing more to help him; moreover, I was afraid that at any moment he might faint. Slowly the rope tightened . . . at last he began to shift, and he was pulled into an upright position by my side. To get a rope around his body was of course hopeless. . . . I tied the best jamming knot I could think of round his arm, just above the elbow. A shout to the rest of the party and he went rapidly upward till he disappeared round the bulge of ice forty feet or more above. Most marvelously no bones had been broken; but how anyone could have fallen as he did, without being instantly killed, will always remain a mystery."

But it is not our purpose to exaggerate the dangers of perhaps the noblest of sports. Let us remember that, while an alpine peak cannot be trifled with, never-

BIVOUAC ABOVE GORGE OF YOHO CANYON.
Too steep for a couch, the guides built a huge scaffolding out into the air, on which the nearest figure is seated.

THE "CLIFF PATHWAY."
Traversed unroped, by party descending from top of great Takakkan fall in 1903.—Glaciers in the background.

theless, under proper guidance and due deference to the voice of experience, mountaineering may be pursued with no more risk than almost any other of the more athletic sports. Since the coming of the Swiss guides, no serious accident has attended the scaling of any one of the many noble peaks that have yielded to the climber's prowess. Year by year, the superb peaks of the first order within a few days' access from the railway have gradually been ascended, until now scarcely one remains. A wider trip afield must be taken, with the necessary struggle with pathless forests and almost impassable gorges, before the bases of several grand peaks as yet unscaled can be reached—doubtless the more arduous part of the undertaking. No one, however, can doubt that the rising generation contains a conqueror for each one of them.

DIGGING SITE FOR UNDERGROUND OF AN OFFICE BUILDING.

Underground New York

A Subterranean World of Marvelous Mechanical Installations and Bustling Activity of which the Ordinary Citizen Has Little Conception

By WILLIAM R. STEWART

Editorial Staff, *Cosmopolitan Magazine*

THE great buildings of New York, which in bewildering sequence rear their daring summits skyward, have produced a city underground of which the visitor to the metropolis sees nothing, and of which the average New Yorker himself has little idea. But if New York could be uncovered, what a spectacle would be revealed! Tiers of sub-stories extending to a greater depth than the bed of the F st River, would dot all the Lower City; batteries of boilers in every block, with explosive energy sufficient to wreck the metropolis, would frown gloomily from the rock-excavated depths; sewers, with their waste and rainfall of a great city, would dry their dank sides in the sunlight; and everywhere huge water and gas mains, pneumatic tubes, telegraph and telephone conduits, and pipes of all sizes, would twist and coil like so many giant pythons in an eastern jungle.

A City's Vitals

It is the very vitals of the city which are below the pavement. There life throbs in every piston thrust, in the hum and buzz of dynamos and fans and the roar of furnaces. The "sky-scrapers" must have their bases well fastened in the earth; and to care for them, there has been evolved a new type of sub-cellar dweller with whom the person who lives overground has not yet had time to familiarize himself. As many as 200 to 300 employees work entirely underground in many of New York's great buildings at the present time. Numbers of these live forty, fifty, and sixty feet below the pavement, where are located the great boilers and engines that furnish the 2,000- or 3,000-horse-power energy which is required to run the elevators, filter and heat the water, make the ice, and perform the other functions of a well-conditioned twentieth century structure.

For six days in the week, sunshine and daylight are strangers to these toilers of the depths. Far over their heads the rattle of the streets is drowned by iron-cased

walls and ceilings; and they live their life as effectually shut out, during the hours of work, from the great world above them as though confined within the dungeons of some modern Bastille. Yet there is this great difference—that in the underground building all is brilliant

forty feet below the pavement. Fifty tons of ice are manufactured there every day, and energy produced to keep illuminated 25,000 electric lights.

Underneath a Sky-Scraper

The undergrounds of the big office

SIX FLOORS UNDERGROUND.

illumination and systematic industry. The sky-scraper overhead must be "run." There are elevators to be operated—fifteen or twenty of them, heat to be furnished in winter and chilled air in summer, water to be filtered, and ice to be manufactured.

In the lower basement of a single large hotel in New York, one hundred tons of coal daily are consumed in the furnaces,

buildings are even more wonderful than those of the great caravansaries. Lower than the bottom of the river which flows not far away, many of them extend; and the machinery which they contain is as perfect as present-day science can produce. Fly-wheels weighing fifty tons, dynamos which generate 2,000 horse-power, pumps, ice plants, hoisting devices, and bins holding 400 to 500 tons

CORNER OF COAL BUNKER UNDERNEATH AN OFFICE BUILDING.—FOUR HUNDRED TONS OF COAL IN SIGHT.

of coal, are some of the features of the building below the street which those who pass above little suspect. To dig and equip the hole under one building alone —that of the Mutual Life Insurance Company, on Nassau Street —cost $800,000.

The underground crew of an office building of the larger class numbers almost a hundred men. These are divided into a chief engineer and two assistants, several other engineers and oilers; and the rest, coal passers, cleaners, carpenters, etc. They work in shifts of eight hours each, and during that time never see the outer air. Well-appointed lavatories and baths afford them all the facilities of the best-appointed private houses, and meals are served underground in perfectly ventilated and brilliantly lighted dining rooms.

An idea of the magnitude and variety of the machinery under the great buildings in New York City is obtained from the estimate that the length of the water, steam, drain, and other pipes in many of them is fully one hundred miles; that from fifteen to twenty-five miles of pipe are required to connect the boilers with the heat-radiators; and that in the private telephone systems of the individual buildings from thirty to forty miles of wire are employed. Over 300,000 gallons of water are used in the principal structures every week-day, each drop of which is filtered in the filtering plant in the basement.

Water and Air Filtered

Indeed, filtering is one of the prime features of the underground life of the New York sky-scraper. Even the air good enough for the person on the street, will not do for the man underground until it is filtered. In all the large buildings of new construction, there is a huge pipe, or shaft, twenty feet or more

square, down which the air is brought from the outside and then forced through a series of cheese-cloth screens which take from it the dust and other foreign substances with which the ordinary atmosphere of the city is laden. So clogged

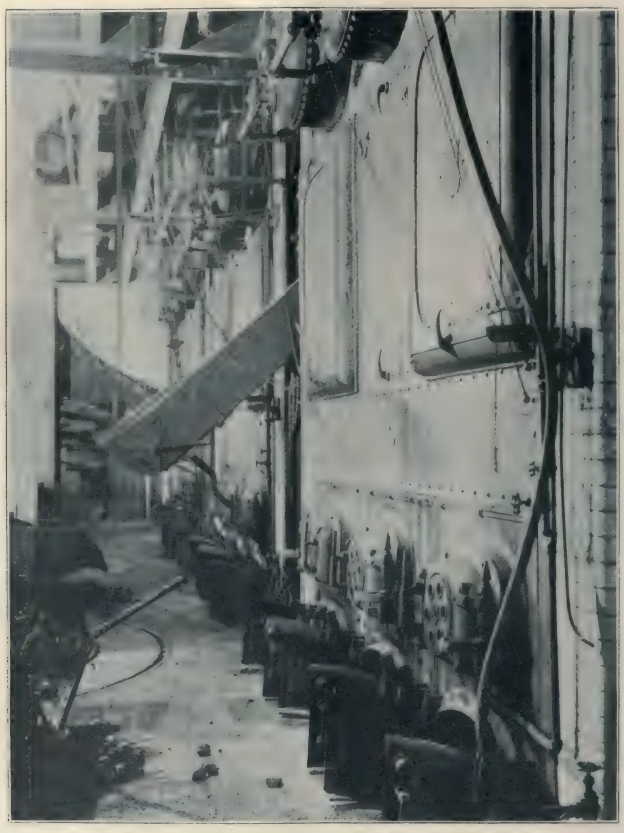
FURNACE IN MUTUAL LIFE BUILDING.
Fifty feet below pavement.—Lower than bed of East River.

do these screens soon become with this dirt that the cheese cloth has to be changed every two days. Beyond the filter chamber, fans and ducts convey the air throughout the underground structure, at the same time creating a draught which supplies the ventilation and forces the foul air into outlets provided for the purpose.

Not only do the underground dwellers thus provide themselves with air which is purer than the millionaire residents of Fifth Avenue have in their drawing-rooms, but they also send the same pure air, pleasantly chilled if the season is summer, to all the floors of the building above them. This is accomplished by means of hundreds of coils of pipes chilled by passing through them cold brine from the refrigerating plant, between the tiers of which coils the air passes after emerging from the cheese-cloth screens. With its temperature thus appreciably reduced, the air is fanned into ducts by great eight- and ten-feet electric fans, and then sent on its com-

forting way. The most complete air-filtering and chilling plant so far installed is under the new Stock Exchange building, on Broad Street.

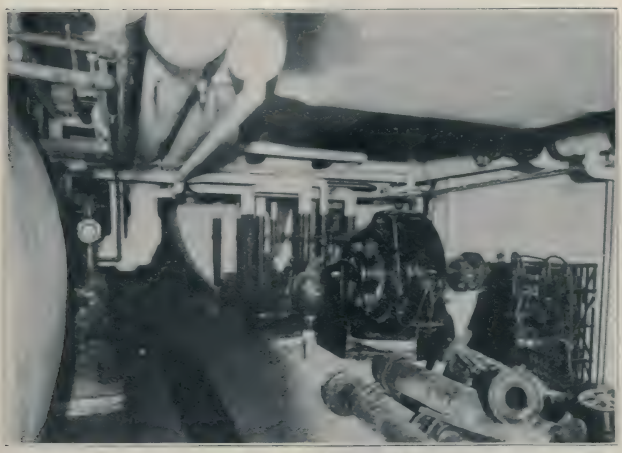
All this machinery is well encased, with sunken caissons and coffer-dams of steel and concrete, to make an imperishable foundation for the mammoth structures that rise above them. Military precision characterizes the management of this plant. The quarters of the chief engineer are accessible within the shortest possible time; and he can be notified instantly, at any hour of the day or night, if anything goes wrong. At any hour of the day or night, too, he is in a position to know, by reference to his charts, at just what rate the coal is being consumed, how many amperes the dynamos are generating, how much water is passing through the filters, or what the steam pressure in the boilers is.



FURNACES OF A SKY-SCRAPER.

A Typical Underground Plant

The mechanical installation underneath one of the great office buildings on lower Nassau Street may be taken as typical of the power plants of underground New York. On the fourth subfloor of this building, thirty-three feet below mean tide-water, are eight great boilers aggregating over 3,000 horsepower; a 10-ton ice machine; fifteen

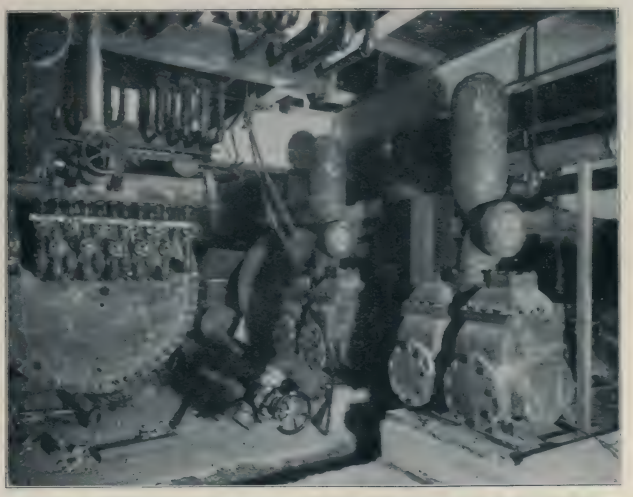


UNDER THE NEW YORK STOCK EXCHANGE.

Dynamo operating one of the fans; also some of the "ducts" by which cooled air is sent from the basement, 52 feet underground, to the floors above.

pumps for house, fire, elevator, and boiler-feeding use; three electric machines; two great feed-water heaters; engines; dynamos; electric ventilating apparatus; automatic sewage ejectors; and ash-lifts.

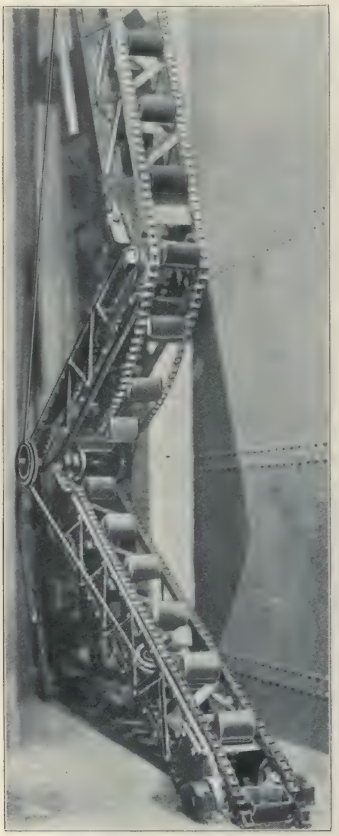
The boilers are of the Babcock & Wilcox type, of 420 horse-power, and need not here be described. The pumps comprise two large Worthington compound-duplex elevator pumps fitted with Corliss valves, the low-pressure cylinder



PART OF REFRIGERATING PLANT UNDER NEW YORK STOCK EXCHANGE.

Showing one of the ammonia machines and two of the pumps by which cold brine is forced into the coils to cool the air.—A similar plant is being installed under the Presbyterian Hospital.

being 34 inches and the high-pressure cylinder 21 inches in diameter; two auxiliary elevator pumps 14 by 20 inches and 15 by 11 inches, respectively; three house pumps to supply wash-room water



Endless Chain for Hoisting Ashes.
Showing, on the right, section of thick copper dam—the armored side—which protects the sky-scraper's vitals.

throughout the building, so hooked up that they can be thrown at once into fire service if needed; three boiler-feed pumps; and four additional elevator pumps, besides those first mentioned. The first four elevator pumps drive ten elevators; the next three, seven elevators; and the two remaining, four elevators. Three elevators (there are twenty-four altogether in the building) are driven by three Sprague electric machines. The remainder of the boiler-room equipment comprises one 2,000-horse-power Berryman feed-water heater and one 1,000-horse-power heater of the same type.

Leaving the fire room, the boilers are connected to a 24-inch header and to a 12-inch auxiliary header, which lead up over the coffer-dam to the main engine room, situated in a cellar under the areaway of three streets. When it enters the engine room, the main is reduced to 20 inches, and then picks up two engines by means of copper bends, and is then again reduced to 14 inches and picks up two more engines. These engines are of the Watts-Campbell type, their dimensions being 28 inches' diameter of piston by 48 inches' stroke, and are connected by a taper bolt-fitted marine coupling to a 16-inch solid steel shaft. The shafts are upset, turned down, and faced to each 350-kilowatt dynamo shaft.

The fly wheel maintaining momentum for each unit (engine to dynamo) weighs 87,000 pounds, is 16 feet in diameter, and makes 70 revolutions per minute. Each unit represents 3,180 amperes, or twice that number of 16-candle-power lights—or, in other words, 6,360 incandescent lights. There being four such units, the total lighting power is represented by 25,440 lamps of 16 candle-power each.

Ventilation is secured by the Stuyvesant system of electric fans, which are similar, so far as type goes, to the small electric fans in use in offices and private houses. In dimensions, however, there is a difference, for these fans have a diameter of from 2½ to 4 feet. There are twenty of them in this particular basement. The air is brought directly from the street and filtered in the manner already described.

Disposal of Refuse

The sewage of a great building is disposed of by means of great tanks, which collect it throughout the building and then are automatically emptied by steam pressure operating to cause a vacuum. The matter in the tanks, upon reaching a certain level, lifts a floating ball, which thereupon opens a ball-cock. The sewage

is then, by the operation of an ejector, lifted from the tank and discharged into the street sewer many feet above. The operation of the principle of the vacuum to effect this discharge is accomplished by an ingenious arrangement of pipes, the steam, when released by the lifting of the ball-cock, being made to produce a vacuum in a duct leading directly from the sewage tank, causing a suction which lifts the material up. The discharge being automatic, the only attention required is to keep up the necessary supply of steam.

The ash-lift is an interesting if a minor feature of the underground plant. To hoist the refuse of the furnaces fifty feet to the street level, there is an endless chain, equipped with buckets, which operates every twenty-four hours for such length of time as is required to hoist all the ashes that have collected. The shovelers simply shovel the debris into the traveling buckets on the chain, and the latter carries them up and dumps them into the carts that are waiting on the street outside.

Initiative

THE world bestows its big prizes, both in money and honors, for but one thing. ¶ And that is Initiative. ¶ What is Initiative? ¶ I'll tell you: It is doing the *right* thing without being told. ¶ But next to doing the thing without being told is to do it when you are told once. That is to say, carry the Message to Garcia: those who can carry a message get high honors, but their pay is not always in proportion. ¶ Next, there are those who never do a thing until they are told twice: such get no honors and small pay. ¶ Next, there are those who do the right thing only when necessity kicks them from behind, and these get indifference instead of honors, and a pittance for pay. This kind spends most of its time polishing a bench with a hard-luck story. ¶ Then, still lower down in the scale than this, we have the fellow who will not do the right thing even when some one goes along to show him how and stays to see that he does it: he is always out of a job, and receives the contempt he deserves, unless he has a rich Pa, in which case Destiny patiently awaits around the corner with a stuffed club. ¶ To which class do you belong? —ELBERT HUBBARD.

A TORNADO'S PATH.
Scene of devastation at Kirksville, Mo., wrought by the great storm of April 27, 1899.

Heaven's Heavy Artillery

Cyclones, Tornadoes, Hurricanes—Their Origin, Area of Operation, and Methods of Action

By JOHN ELFRETH WATKINS

A ROARING, snapping, death-sowing funnel-cloud looms up in the sky, descends to earth, ploughs through life and property for a mile or two, ascends into the air whence it came, and passes off. Ten to one the newspapers will state that a "cyclone" visited the affected region. It all results from our eternal, inveterate habit of sticking to wrong names—for example, "locust" for *cicada*, "buffalo" for *bison*, and other misused terms that might be cited.

Various Kinds of Storms

The funnel-cloud phenomenon briefly described above, is a *tornado*. The name we have appropriated from the Spanish, and it means "turned" or "twisted." It is applied by meteorologists to local storms of very short duration, but yet the most violent wind disturbances known to man. The weather man will show you on his map that there are *cyclones* active within our boundaries every minute of every day. Cyclones, according to the correct application of the term, are the ordinary, general storms moving over the continent, which they enter from the northwest or southwest, and which they leave in the neighborhood of the Gulf of St. Lawrence. They visit us at all seasons, but are most vigorous in winter. They are great whirlwinds whose vortices are hundreds of miles in diameter.

Hurricanes constitute a third class of storms, one confused with both tornadoes and cyclones. They come upon us from the south or southeast, originate usually in the eastern Caribbean Sea, and travel generally in a curved track, up our coasts, going first northwestward, then northward, and eventually northeastward, toward the general storm exit near the Gulf of St. Lawrence, above referred to. They occur in late summer or early autumn, and are much more violent than cyclones, having a velocity of sixty to eighty miles an hour at their centers. They cause destruction to cities and towns which they visit, but especially to shipping along the coast.

While cyclones may be 1,000 miles in diameter, and hurricanes somewhat less —about 600 or 800 miles—a tornado is only a mile or two broad at the top, and only a few rods at the bottom.

The Tornado a Cyclone's Child

The tornado cloud is a long, slender funnel tapering from the sky toward the ground. In the innermost part of its whirl, the wind is blowing at a speed of 200 or more miles per hour—about four or more times as fast as our express trains—and produces against the side of a house a pressure of 200 pounds or more per square foot. Its destructive effects are confined very closely to the path of the funnel through the visited strip of country, and, in the Northern Hemisphere, for some reason, are always more severe on the south than on the north side of this path's center. The affected strip is usually but a few rods wide and a few miles long, the total area involved being generally less than a square mile. The duration of one of these most confined yet most deadly of storms, is generally but a few minutes, whereas a cyclone or hurricane will remain within our boundaries for days at a time.

Tornadoes generally travel from the southwest toward the northeast. Their funnels, in the Northern Hemisphere, revolve in a direction opposite to that of the hands of a watch held dial upward—a characteristic of cyclones as well. In the Southern Hemisphere, a truly clockwise motion is invariable. While a cyclone is a mile or two deep, a tornado is only several hundred feet from top to bottom.

TORNADO IN OPERATION.
From a sketch.

The conditions preceding a tornado

TORNADO FUNNEL-CLOUD APPROACHING.
View taken in Oklahoma.

are those of a thunderstorm exaggerated. Such visitations occur in the warm season, in the warmer hours of the day, and in very moist air. Late spring is the danger period in the South; early summer, in the North. Very intense electrical phenomena often accompany such disturbances; torrential rain—often hail—either accompanies or follows. The approach of the funnel-cloud is heralded by a roar comparable to what would issue from hundreds of railway trains approaching at high speed. Often the vortex itself cannot be seen, even in midday.

Occurring at sea, a tornado is known as a "waterspout;" in the desert, as a "sand storm." Sometimes, on the Lakes or on land, they form in a clear sky, and are then known as "fair weather whirlwinds;" but these are usually small and of little severity. Occasionally they pass over the earth in the form of a small white funnel-cloud, high up, in a dry atmosphere; then they are known as "white squalls." Quite similar are the "bull's-eye squalls" occurring near the

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GREAT LOUISVILLE TORNADO OF MARCH 27, 1890.
Corner of Market and 11th Streets.

west coast of Africa. Waterspouts, very small, are sometimes experienced at sea or along the seacoast, in clear, calm weather.

Tornadoes are the children of cyclones. They are generally formed along the southeastern edges of these larger storms, and at first move forward at about the same speed as the latter. We often see in the cloud regions minor whirls which have a gyratory motion. These frequently are the first stages of a tornado's evolution.

FLOUR MILL WRECKED BY TORDADO AT ROCHESTER, MINN., AUGUST 21, 1883.

Not a single offspring, but often a large litter of tornadoes are produced from a cyclone at one birth. As many as fifteen tornado tubes, or funnels, have been observed coming down from the same cloud.

Earth's Great Cloud-Shell

The process of tornado creation is now very well understood by meteorologists. But before their explanation can be understood by the general reader, he must first know something about Earth's great cloud-shell floating above; for, concerning this, man had known but little until a few years ago when the great scientific nations set to work at an international survey of the clouds.

"It has been shown by the cloud observations, that the strata of the upper and of the lower layers of the air have very different kinds of motions over the United States," says Prof. Frank H. Bigelow, of the United States Weather Bureau, who had charge of our co-operative work in the great cloud survey, and to whom the writer is indebted for many of the facts embodied in this article. "The upper levels move almost directly to the eastward at a great rate of speed, like a steady river flowing onward with but little to disturb its majestic current." The higher the clouds forming this "majestic current," the greater their speed, until the highest—about six miles above us—travel at a rate of 80 to 90 miles per hour, or about a half again as fast as our swiftest trains. From the level of the ground up to a height of about two miles, the air carries the clouds, not in one general current, but in great circulating streams, having greater velocity as the height increases toward the uniform drift at the top.

"The steady eastward movement in the upper levels, is replaced (in those below) by a confused set of currents squirming about among themselves—cold streams from the north, warm streams from the south, seeking to reduce their differing temperatures to the mean temperature of equilibrium. These streams are thousands of miles in length, say from the north Pacific coast to the Lakes, and

from the Gulf of Mexico to the same region, where they produce a whirling or 'cyclonic' action by their meeting together in a counterflow."

Tornadoes as well as cyclones, therefore, are formed by a warm current of moist air from the Tropics, and a cold, dry current from the northwest, meeting each other, forming a true vortex motion—like meeting currents of water. In the center of the vortex is an uplifting current which raises the moisture-bearing air from the lower levels near the earth to the colder levels above, where the moisture is precipitated in the form of rain. It is summer, and the warm weather is at its maximum. The interior of the country is heated; the maratime districts are comparatively cool. The two winds meet in the central valleys. The cool and warm currents are drawn out into long bands or ribbons. In certain cases a tornado tube is projected, spinning top-like, downward from the congested air. This is the typical case.

A KANSAS "CYCLONE CELLAR."
One of the typical underground retreats in which safety is sought on warning of an approaching tornado.

In the tornado there is a reversion of the process of firing a gun. When a gun is discharged, there is a sudden formation and expansion of gas. When a tornado is formed, there is a sudden production of a vacuum into which outside air discharges itself.

How a Tornado Acts

A typical tornado acts as follows:—It is a funnel-shaped tube a half-mile high, 6,000 feet in diameter at the top, 100 feet in diameter at the bottom. It travels with a forward motion, covering 15 to 60 miles per hour. The outer edge of the top revolves at the rate of 7 miles per hour; the rim near the bottom of the vortex, at 200 miles per hour. In the lower tube is thus produced tremendous centrifugal force, a partial vacuum causing objects in its path to explode and producing a low temperature. This cold generates the sheath of vapor that makes the funnel visible, in the form of a cloud, and causes a condensation producing electric discharges—just as in thunder-storms on a large scale. The tornado's duration may vary from a few minutes to several hours. The wind's great velocity prostrates every obstacle in its path. Its effect is not only to hurl objects before it, and to produce an explosive action in its vacuum, but also to lift bodies in a vertical direction. A velocity as high as 600 miles per hour in the lower tube, has been reported.

Measurements of some recent tornadoes have been computed by meteorologists. The great waterspout of August 19, 1896, in Vineyard Sound, seven and a-half miles northeast of Cottage City, Mass., had a tube extending from the cloud to the surface of the sea, a distance of 4,200 feet; was 3,400 feet in diameter at the top, 170 feet at the narrowest part (1,500 feet above the

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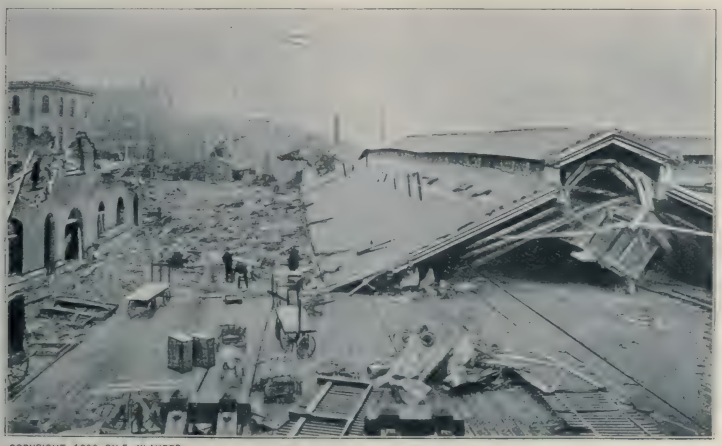
WRECK OF CENTRAL AND OTHER TOBACCO WAREHOUSES IN LOUISVILLE, KY.
Some of the effects of the tornado of March 27, 1890.

sea), and 250 feet at sea-level. It revolved at the rate of 14 miles per hour at the top, and 350 miles per hour at the bottom.

The air just outside the funnel of a tornado is undisturbed, and the sudden contact of the tube is like the heavy blow of a battering-ram. The force of the Vineyard Sound waterspout—one of the largest tornadoes of its class—is estimated to have been 330 pounds to the square foot, at the maximum.

No structure can be built strong enough to withstand the vortex of a tornado in full power. If the structural strength of buildings is such, however, that they will resist a pressure of at least 40 pounds per square foot applied laterally against their walls, they will, in Professor Bigelow's opinion, stand against such extraordinary storms as hurricanes. It is estimated that the great St. Louis tornado of 1896 exerted upon the destroyed Eads bridge and upon



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WRECK OF UNION RAILWAY STATION, LOUISVILLE, KY., MARCH 27, 1890.

RESIDENCE WRECKED BY A TORNADO.
At this point a mother and her daughter were killed, and two other persons injured.

heavy buildings a pressure of at least 60 to 90 pounds per square foot.

Area Most Frequently Visited

The tornadoes of the United States occur frequently in the Mississippi and Ohio valleys. However, there are few States east of the Rockies which are not occasionally devastated by such phenomena. The Rocky Mountain plateau and slope, however, are free from such visitations. In the central valleys they are of annual occurrence. In the winter months, they occur only in the Gulf States; but, as the weather grows warmer, they extend northward, and in the summer are of greatest frequency in Nebraska, South Dakota, Iowa, and Minnesota.

They are more frequent in the months of May and June than in other parts of the year, owing to the fact that local contrasts in temperatures are greater in the spring season than in summer or winter. Twenty-five tornadoes per year is the average in the United States, and this frequency is quite uniform from year to year. About three destructive tornadoes of great violence occur each year. There seems to be no annual increase.

There is believed to be some possibility of a connection between the frequency of sun spots and the recurrence of tornadoes. In fact all elements of weather may be indirectly connected with sun spots, through the general circulation of the atmosphere.

Means of Safety

Tornadoes have been dispelled by cannon shots, at sea. Their funnels will resist an explosive discharge in the outside air, and this fact led a meteorologist some few years ago to suggest that heavy artillery be mounted at intervals along the boundaries of the territory wherein these storms are most frequent. Conservative meteorologists, however, scouted this proposition. There is, in their opinion, no practical way of warding off tornadoes when conditions are favorable to their development. In many parts of the tornado belt of the Middle West, excavations known as "cyclone cellars" are made near to houses. These are sheltered by roofs, generally of framework, or often are crowned by a low mound and partial superstructure containing a door. When a funnel-shaped cloud is seen to approach, all members of the household thus fortified retreat to the subterranean asylum, and wait until the wrath of the winds has been appeased.

PIANO CARRIED 1,000 FEET AND DROPPED THROUGH THE ROOF OF A HOUSE.

To find safety from a tornado, it has been suggested that persons not so fortified should run to the north or northwest of its evident path, or take refuge in a cellar, preferably that of a frame house. Noticeably few deaths from tornadoes have occurred in the cellars of wooden houses. It has been suggested above that the destructive effects of such a dread phenomenon are noticeably more severe on the south side of the funnel's central track. This is for the reason that on this south side there are strong indraughts extending for some distance. It might be fatal to run not only to the south, but to the northeast, as our tornadoes follow this latter direction.

Tornadoes have performed a great variety of feats. While one will lift a locomotive from the rails, carry it a goodly distance, and replace it on the ground, practically uninjured, another will grind a stately building to dust. Straws and cards have been shot like bullets, through the bark of trees. Houses have been carried away, leaving their unsuspecting occupants safe, though unsheltered.

Efforts to forecast tornadoes accurately, are being made by meteorologists. Warnings sent ahead of the great St. Louis tornado of 1896, were so well heeded that schools were dismissed before the funnel-cloud ploughed through the city.

Historic Instances

Our banner year for frequency of tornadoes was 1884. In a period of fifteen years, the Weather Bureau reported 830 days on which such dread storms occurred. From 1889 to 1898, the estimated total loss from this class of atmospheric upheavals was $25,000,000.

The definite record of highly destructive tornadoes visiting our country, commences May 7, 1840, when, in Adams county, Mississippi, 317 people were killed and 100 others injured, and property to the value of $1,260,000 was destroyed. The same county was visited by a similar convulsion two years later —or on June 16, 1842—when 500 persons lost their lives.

CENTER OF WRECK AT KIRKSVILLE, MO., APRIL 27, 1890.

The case of Louisville in 1890, more fully described below, may be cited as another instance exemplifying that one stroke from such an aërial bolt implies no immunity against a repetition, for on August 27, 1854, a tornado tube had passed through the city, killing 25 people and injuring 67.

The town of Montevallo, Ala., was practically wiped out by one of these storms, November 22, 1874. One hundred houses — about all the settlement could boast of—were destroyed. Near Erie, Pa., July 26, 1875, a tornado killed 134 people and caused a property loss of half a million dollars. A hundred buildings were destroyed, and thirteen people killed, by a funnel-cloud which swept through Ray county, Missouri, June 1, 1878.

As far north as New Haven, Conn., a tornado destroyed 160 buildings and

killed 34 people on August 9, 1878. The property loss there was $2,000,000. Several tornadoes swept over Kansas on Decoration Day, 1879, causing a great loss of life; while four different counties in Missouri were despoiled, April 18, 1880, a hundred people losing their lives, 600 others being maimed, and 200 buildings being wrecked, at a total property

Destruction at Grinnell, Iowa.
Residence of Professor Buck, wrecked by tornado, June 17, 1882.

loss of $1,000,000. A hundred people were killed, 300 were injured, and 260 buildings were destroyed, involving a loss of $1,000,000, at Grinnell, Ia., June 17, 1882. Exactly one week later, Emmetsburg, also in Iowa, lost a hundred citizens from the same cause.

On February 9, 1884, an unparalleled series of tornadoes—over 60 in all— occuring in each instance after 10 o'clock A. M., devastated parts of Illinois, Kentucky, Mississippi, Georgia, Tennessee, Virginia, and the Carolinas. Fully 800 people were killed, and 2,500 injured, and 10,000 buildings were destroyed. On September 9, in the same year, 305 buildings and $4,000,000 worth of property were destroyed by a tornado ploughing through parts of Wisconsin. Five hundred buildings were wrecked at Camden, N. J., August 3, 1885, by a tornado which caused a property loss of half a million. Another, on January 9, 1899, wrecked the suspension bridge at Niagara Falls. The same tornado is supposed to have struck Reading and Pittsburg, Pa., on that day.

Louisville's second tornado, after a lapse of 36 years, occurred on March 27, 1890. The afternoon papers of that fatal day published a notice from the National Weather Bureau, Washington, warning Louisville and vicinity that severe local storms and atmospheric troubles were approaching. Shortly after nightfall there came a heavy fall of rain, followed by a hailstorm accompanied with severe lightning. The wind later began to blow with a mournful sound, which soon increased to a "frightful shriek" as it swept over the doomed portion of the city. The crisis of the calamity occurred about 8:30 P. M., and was over in a few minutes. A patch 1,000 feet wide was ploughed through the city, destroying in those few moments 5 churches, the Union railroad depot, 2 public halls, 3 schools, 266 stores, 32 manufacturing establishments, 10 tobacco warehouses, and 532 residences—all within the city limits. The pecuniary loss was estimated, after careful tabulation, at $2,150,000. But the more irreparable loss was that of 76 human lives, while over 200 people were injured. Many lives were lost the same day in small towns, not only in Kentucky, but also in Illinois, Indiana, and Tennessee.

"Such a calamity can be paralleled only in some convulsion of nature, fortunately of infrequent occurrence, such as an earthquake, a volcanic eruption, or a great tidal wave," stated Maj. H. H. C. Dunwoody, assistant chief of the Weather Bureau at that time.

Massachusetts was visited on July 26, 1890, when a path 200 feet wide was cut through the town of South Lawrence. Although this was the most destructive tornado ever reported from New England, only 9 lives were lost and 40 people were injured.

Waterspouts, tornadoes, and other violent storms invaded various parts of the Mississippi valley on July 6, 1895, two months and three days after a tornado had killed more than 100 people in Iowa.

But the worst catastrophe was yet to come. The details of the terrible tornado

which devastated St. Louis and East St. Louis on May 27, 1896, are fresh in the public memory. Five hundred killed, 1,500 maimed, and a property loss of $14,348,350, was the tribute paid to that single convulsion of nature. The same year, on August 19, off Cottage City, Mass., occurred the great waterspout described above.

Two hundred and fifty lives were lost in a tornado striking New Richmond, Wisconsin, June 12, 1899. Less than two months before—on April 27—a storm of the same class ploughing through northern Missouri killed 42 people and injured more than 100. This storm was especially disastrous at Newton and Kirksville. At the latter place, a piano was carried 1,000 feet and dropped through the roof of a house.

Inventions

Problem of Realizing on a Patent after it Has Been Granted

Third Paper*

By EVERETT E. KENT

Counselor-at-Law and Patent Attorney

"Our future progress and prosperity depend upon our ability to equal, if not surpass, other nations in the enlargement and advance of science, industry, and commerce. To invention we must turn as one of the most powerful aids in the accomplishment of such a result."—PRESIDENT MCKINLEY in his Annual Message of December 5, 1899.

TO the high aim set forth in the above words of the late President McKinley, the original framers of the Constitution looked forward. For this purpose, Congress, adopting the recommendation of President Washington to give "effectual encouragement," has enacted laws—from 1790 down to the present day.

The patent system of the United States is a system of contracts between the Government and the inventors. In consideration that the inventor discloses his new and useful invention to the public in the best form in which he contemplates using it, and in such full, clear, and exact terms that any person skilled in the art can understand and practice it, the Government grants to the inventor and his assigns a monopoly for seventeen years, covering the thing so described and claimed. If the inventor fails to comply with his part, or if the invention ever proves not to have been "new and useful," the patent is proportionately void. Subject to these qualifications, the monopoly is absolute in the fullest sense of the word. The patentee may use the invention himself alone, or license a select few others to use it, or suppress it entirely. The power of the judicial and executive branches of the national Government is at his command to enforce

*NOTE.—This is the final paper of Mr. Kent's series on "Inventions." The first and second papers appeared in THE TECHNICAL WORLD for December, 1904, and January, 1905, respectively.

the monopoly. There is no limit to the price he may charge to consumers, except the utmost the traffic will bear.

In these days of trusts and combinations, let the reader remember, the next time he is asked to pay a seemingly outrageous price for a patented article, that this is the price of progress. It is no "robbery;" it is the fair reward guaranteed by the Constitution and by laws of Congress, for a limited time, to induce some one to make and introduce that article. It is the main basis of the wonderful industrial progress of the United States during the last century, and of the material comforts which every man enjoys so commonly in his home to-day. The reader is not compelled to buy the article if he thinks the price too high. He is free to continue doing as he did before the invention was made.

Necessary Preliminaries

In estimating the possibilities, the patentee must remember that the making of the invention is only one step toward the ultimate profit. Placing the invention on the market; making patterns and castings; experiments; manufacturing and carrying on hand a stock; bringing it to the knowledge of people; persuading them to buy; overcoming opposition—these are other steps that must be accomplished before the profit begins to flow in; and whoever contributes them is entitled to be paid, just as truly as the man who contributes the inventive idea.

A struggle is raging to-day throughout the southern part of the United States, between the present system of compressing cotton into bales for shipment to the mills, and two new methods. These new systems each make great savings possible to owners of cotton, to shippers, to railroads, to steamships, to insurance companies; and they deliver the cotton to the buyer in Europe, in neat, clean bales. But—and "there's the rub"—they can be introduced only at the cost of turning into the scrap heap the compresses now everywhere in use and the enormous investments they represent. That touches a tender spot. Some day the men introducing these systems will be honored; but thus far, after ten years' effort, they have succeeded in getting barely two per cent of the business. Millions, contributed by investors who have faith in the future, have been spent in the fight; and the end is not yet. The new is bound to triumph in the long run; but meanwhile the capitalist is mightily out of pocket. Small wonder that inasmuch as he bears the loss, he demands some sizable portion of the gain. Just *how* much he should have, is matter for bargaining between him and the inventor at the outset.

Planning the Campaign

An inventor has a certain comfortable feeling in looking forward to a monthly income of five hundred or five thousand dollars; but how to get it, is a real question. The proper price to charge, and the proper way to handle a patent, are matters worthy of serious and careful study. The ultimate value of the patent depends largely upon their wise determination — assuming, of course, that the patent is sound and covers a meritorious article. "The utmost the traffic will bear" is not always the highest price. Sometimes, by charging a smaller profit on each scale, a greater total profit is gained because of the greater volume of sales. The market and its possibilities must be studied thoroughly.

One way to get at the worth of a patent is to deduct from the selling price of the article the cost of the stock and manufacture, a profit for the work of manufacture (usually 10 per cent), and the cost of advertising, distributing, and selling. Then, after deducting a further sum as a reasonable profit on managing the business, the surplus may be credited to the patent. Account must also be taken of the maximum possibilities to which the business can be developed on the strength of the patent. If the business is not yet established, these matters must be estimated, and the result figured out in different ways in order to learn the best.

Other things to be considered are: —Whether there will be a lucrative trade in furnishing supplies to go with the article; whether the article is valuable only for itself, or is capable of being used as a "business getter" for something else. The owner of a delicate regulating device for a turbine may, by means of it, get contracts for furnishing the turbines

themselves; in which case, in addition to the profit on his regulator, he gets the normal business profit on manufacture of the whole machine. Sometimes a patent can be divided into separate rights. If so, the patentee can probably get nearly as much from the purchaser of each single right as that purchaser would pay him for all the rights put together. The Goodyear rubber patent was thus divided, the owner licensing one concern to make rubber shoes, another clothing, another tubing, another combs, etc. Again, it is important whether much or little capital is needed, and whether there is a continuing expense. A telephone system has to be constantly supervised by experts, while an artificial sidewalk can be sold once for all. The latter, being essentially a local business, can wisely be divided into territorial rights or licenses; the telephone can also be divided, or can be worked as a unit.

The patent may be sold for a lump sum or a royalty. On the principle that a bird in the hand is worth two in the bush, an inventor will sometimes get more by selling his invention for a lump sum at the start. As a rule, however, the main profit from a patent is derived by the person who holds and exploits it year after year. In return for this greater chance of gain, this person has to stand the risk of loss in case a substitute and non-infringing device is subsequently invented; and he has to bear the financial burden and risks of carrying on the business. The article, possibly, may be of short-lived vogue, like "Pigs in Clover," though immensely profitable while it lasts; or the patent may be proved to be invalid.

Sometimes a patentee can sell separate territorial rights in each state or county. There are nearly 3,000 counties in the United States. Suppose county rights were sold at $10 each, with provision for a small royalty on sales. The inventor would net a comfortable sum whether any sales of the articles were subsequently made or not.

The patent can be worked on a royalty basis with very little capital. The patentee must have enough to take the necessary steps towards placing the patent and looking after it. In fixing the royalty, the cost of collecting the same and of a proper supervision over the extent of the licensee's use should be remembered; and every royalty contract which grants an exclusive right should contain a clause guaranteeing an annual minimum payment, lest the licensee, having got possession of the patent, should put it away unused and no royalty accrue.

Specimen Problems

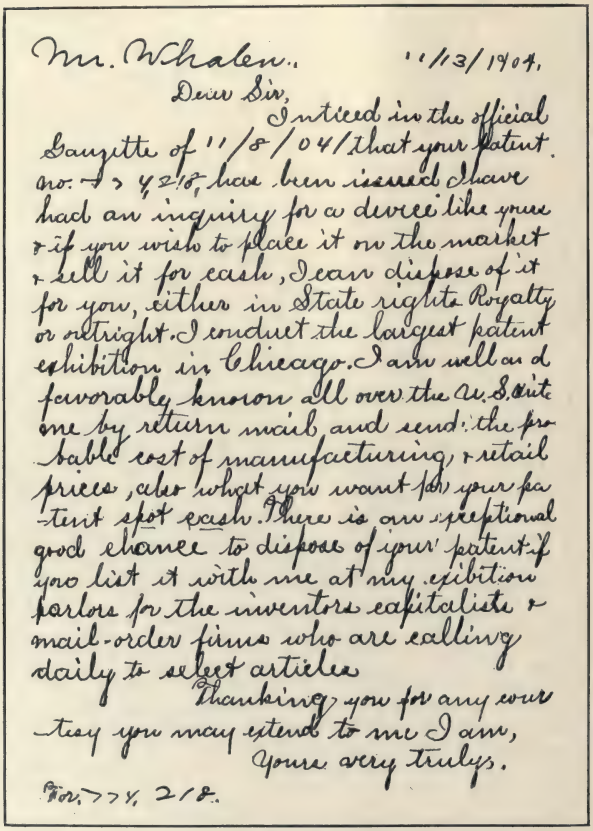
Let us consider three different kinds of inventions:

First.—Some article of general use—say a shipping tag. This can be made and sold by the inventor himself, if he wishes. The article is salable to numerous consumers all over the country, and can be supplied from a central factory. The total probable sales can be estimated, and from them the total profit; thus a valuation for the patent can be arrived at with a fair degree of accuracy. If the patentee wishes to work it himself, but lacks capital, he can sell some territorial rights, and thus raise capital to work the remaining territory himself. If an offer of a lump sum is made for the patent, he can judge whether it is adequate. If inadequate, he can afford to wait, even though he does only a small business in the meantime; the patent will be more salable rather than less as time goes on and as the invention becomes better known.

Second.—Suppose the invention to be one of the new kinds of rapid-cutting tool steels. Such a patent may be worked by making and selling tools, or by selling the patented steel to makers of tools, or by licensing one or more concerns to make the steel itself. Inventions of this character are so new that the scope of the market for them and the real value of the invention cannot be accurately judged at the present day. All that is known about the future of such steels is that the demand for them will ultimately be enormous. Which particular kind will live in the fight, and how low profits will be cut, it is too early to estimate. Hence, if a man sells such a patent for a lump sum, he must sell it at what may prove to be a sacrifice. If he delays, or if he sells on a royalty basis, he may get a larger sum; but he takes the chance of seeing his possible profits

fly away because of a cheaper and non-infringing process subsequently invented.

Third. — Suppose the invention be a new kind of armor-plate. This may be an immensely profitable invention; but it is an article which the inventor cannot make himself, and for which there are but few possible purchasers. He is practically obliged to take the best offer he can get without delay; for, if a better armor-plate be devised, his market will be gone, it being a cardinal principle of naval architecture to use only the very best.



Mr. Whalen. 11/13/1904.

Dear Sir,

I noticed in the official Gazette of 11/8/04 that your patent no. 774,218 has been issued. I have had an inquiry for a device like yours & if you wish to place it on the market & sell it for cash, I can dispose of it for you, either in State rights Royalty or outright. I conduct the largest patent exhibition in Chicago. I am well & favorably known all over the U.S. Write me by return mail and send the probable cost of manufacturing, retail prices, also what you want for your patent spot cash. There is an exceptional good chance to dispose of your patent if you list it with me at my exhibition parlors for the inventors capitalists & mail-order firms who are calling daily to select articles.

Thanking you for any courtesy you may extend to me I am,

Yours very truly,

For 774,218.

FACSIMILE OF POSTAL CARD SENT TO PATENTEE BY AN "AGENCY."

Volunteer Assistants

The inventor who survives the first fortnight after the grant of his patent without an acute attack of "swelled head," is a rarity—or else he has had previous experience. Hardly is the patent issued when the postman begins bringing him mail by the bushel, from all over the United States, and even from Canada and Europe, praising the invention and declaring it is just what the public have been longing for, with a yearning that could not be uttered — and the writers respectfully solicit the privilege of selling the patent upon a small commission.

One such missive — at first glance appearing to be a hand-written postal card, is illustrated herewith, the sender's name being removed. Close inspection, however, shows that this handwriting is really not written, as it looks, but is printed by some lithographic process, except the address, the date, and the number of the patent. These are inserted by hand in an ink closely matching that in which the rest of the card is printed. The reader will also perceive, upon close inspection, that the handwriting of the inserted portions differs from the rest; but ordinarily a person receiving the card would not notice this. The errors in spelling in the lithographed portion add to the illusion. Many recent patentees

will recognize this illustration as a reproduction of a card which they also received, except that each found his own name, date, and number in the place here occupied by another. The wording of the card will fit any sort of device. Of course, the recipient is not aware that the same flattering statement is mailed to a large number of other patentees each week. Does anyone believe that this "agent" has actually "had an inquiry" for the devices of *all* of them?

As a matter of fact, this particular patent relates to an improvement in the mail-boxes used by the Government for collection of letters at street corners, etc. To say that the sender of the postal card has "had an inquiry for a device like yours" and "can dispose of it for you, either in state rights, royalty, or outright," is absurd. Undoubtedly this improvement will be of great benefit to the public in each State, if the Government adopts it; but it is not the sort of thing for which "state rights" can be sold.

Subsequent correspondence showed that the "agent" was anxious to receive a preliminary registration fee of ten dollars, upon receipt of which he would try to sell the patent; and would ask no pay for his services unless a sale were effected. So far as the author of this paper knows, that would be done sincerely; but there is a suspicion that a comfortable living can be made from registration fees alone, even if the efforts to sell are unsuccessful. For instance: Suppose that only ten patentees each week out of the weekly crop of five hundred, more or less, are induced to send the "agent" ten dollars each. Figure it out.

This is mentioned merely as a type of the offers a patentee receives. Other "agents" desire to procure Canadian and foreign patents for the inventor, always at bargain prices, and usually accompanied by testimonials having a strong savor of quack medicine advertisements. The patentee ought to remember the advice previously given:—

Services really worth having, cost money.

Men who are really competent do not need to cut rates.

A matter worth doing at all is worth doing *right*.

"Working" the Inventor

The confident inventor is sometimes "worked" as follows:

A firm of "bankers and brokers," with an impressive letter-head, write that they are in the business of promoting and financing new inventions, and would like to take hold of Mr. X's patent, as it looks profitable. They suggest forming a corporation, say of $100,000 capital stock, giving the majority of the stock to the patentee. The broker will do all the business of incorporating, and will not ask for any fee until the company is successfully under way, but will then receive a commission on whatever stock he succeeds in selling. This idea is so plausible that the victim assents. Then the broker explains that in order to make the scheme a success it is necessary for some big Trust Company to act as trustee. The broker will arrange all that; but $500 will be necessary to pay the Trust Company for its services, and to pay for preparing the papers, opinion of the Trust Company's counsel, etc., etc. This also is plausible; the client advances the money; and a corporation is formed. After long delay, the client becomes impatient, and is finally informed by the broker that it has proven impossible to sell any stock, because no investors were satisfied with the proposition. Result:—client $500 out; broker $300 in. Sometimes the Trust Company "wrinkle" is left out, but the effect is the same.

The moral is—Deal only with thoroughly trustworthy people. Don't be misled by appearances. This does not mean that no agent or broker may be employed, or no corporation formed. Salesmanship and the art of negotiating are specialties just as much as the art of stone-cutting or of oratory; and frequently the formation of a corporation is the very best way to finance a patent. —Only, don't be gullible. Inventors and men of genius are proverbially poor business men.

How to Sell

One method of selling a patent or getting capital is as follows:—

First. Find a man with sufficient money. Advertise, if necessary. A man who is familiar with the particular business to which the invention relates will

most easily appreciate the true value of the patent.

Second. Make him understand the invention and see the value in it. A clear drawing helps in this, with a simple printed description. These should be neat, accurate, and clear. In addition, and far more convincing, is a working specimen, or what is sometimes called a "working model."

Third. Most convincing of all is the record of actual manufacture and sales showing clearly what it costs to build the thing, how it can be sold, and how well it appeals to the public. No argument is so conclusive as the fact of profits actually made. Therefore, get a business started; capital will then come in and spread the business over the country. Atwood, the inventor of the sun burner and straight chimney, having failed to induce manufacturers to place his improvements on the market, borrowed the money to have his patented articles made, and then himself peddled the same from an open wagon around the streets of Chelsea, Massachusetts. In eight years thereafter, he had accumulated seven or eight hundred thousand dollars out of his invention.

Fourth. A man who is by temperament or experience a salesman or solicitor can sell goods and get capital where another man would fail. The assistance of such a man is valuable.

Fifth. If you have a good article and your efforts are unsuccessful at first, don't give up. Be diligent. Keep everlastingly at it.

When a sale or agreement is about to be consummated, a lawyer should invariably be consulted to prepare the papers—a lawyer having experience in dealing with patent rights. The dangers are too great to justify unskilled persons in preparing the papers themselves. Special warning must be given against the use of the form of assignment of an undivided interest in Letters Patent, contained in the appendix to the "Rules of Practice" published by the Patent Office. That form is, no doubt, sufficient for its purposes, and a pitifully large number of the patents issued each week are assigned in that way. The objection is that this form of assignment results in each person, assignor and assignee, having the right to use the invention as freely as if he owned the whole of it, and to license others to use it, but with no check on competition between the owners, and neither having any right to share in the profits made by the other. A better way is to have a title stand in the name of a single person—a trustee, if need be; and to have the intended rights and duties of the respective parties clearly defined in the instrument.

From the Buyer's Standpoint

All patents issued are presumed to be valid; but the Government does not guarantee their validity, and a seller of a patent cannot wisely give such a guarantee. The official search may have overlooked some anticipating patent. Frequently the prior art contains somewhat similar devices which the Examiner did not have occasion to mention, but which materially affect the scope of the patent in question. Consequently every buyer of a patent should have an exhaustive search of the records made, and an expert opinion as to the scope and validity of the patent. If he and all the public are free to make some device equally good, which is disclosed by the search and is not covered by the patent, he is foolish to pay money for the patent. Every intending competitor ordinarily makes a similar search in order to find, if possible, a lawful competing method. The buyer should also have a search of the title records made, just as in the case of real estate.

If an invention proves commercially successful, a host of infringers spring up—people who seek either honestly or dishonestly to obtain for themselves some of the fruits of the invention. The patentee, on proving his case, may get a writ of injunction from a Circuit Court of the United States, restraining any such person from infringement, and awarding to the patentee the damages he has suffered, and the profits which the infringer has made. If the infringer continues, the Court will fine or imprison him as for contempt of court. The getting of an injunction consumes a number of months, and sometimes years; but when the validity of a patent has once been established, the Court will grant injunction promptly, and the patentee remains in command of the field during the remaining life of the patent.

Air-Compressors

Principles and Mechanical Details of the Various Commercial Types of Air-Blowers and Compressors

By S. H. BUNNELL

Master of Works, Watertown Engine Company, Watertown, N. Y.

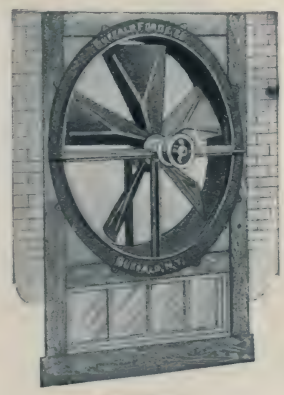
THE various practical applications of compressed air cover a range of pressure from a fraction of an ounce to several thousand pounds per square inch. To produce the required supply of air with proper pressure and economy, numerous types of compressors, each having its peculiar and appropriate field, have been designed. These are, in the order of the pressure produced:—the disc fan, the centrifugal blower, the positive blower, the blowing engine, the direct-acting compressor, and the compressor with crank and flywheel. By the operation of all these, the same result is produced—the delivery of a quantity of air under an increased pressure and correspondingly increased temperature, and the subsequent rapid loss by the air of its excess of temperature, with a proportionate decrease in volume. Most of the problems in the design of compressors are created by the heating of the air during compression and by the effects so produced upon the apparatus.

The Disc Fan

The disc fan, corresponding to the marine screw propeller in action, is useful for producing a flow of air of considerable volume but with almost inappreciable increase of pressure. It is thus suitable for purposes of ventilation in expelling foul air, gases, or smoke, or for removing dust, fine shavings, and waste particles from woodworking and grinding machines. The power expended in revolving the fan goes in great part towards whirling the air current around in the fan casing and pipe—a waste of effort which limits the application of this device to conditions of moderate speed and very light pressure.

The Centrifugal Blower

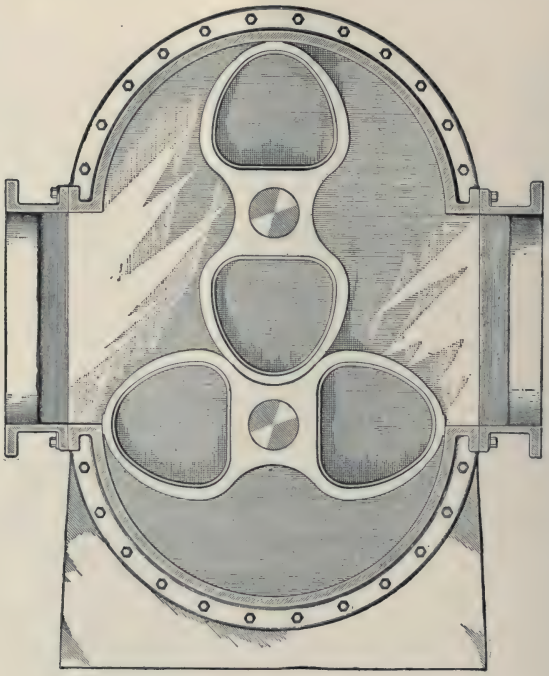
By taking advantage of the tendency of revolving particles to fly away at a tangent, a fan blower of better efficiency and a wider field of usefulness is afforded. Particles of air whirled around by the blades of the disc fan merely fly out and press against the casing; but the centrifugal blower converts this action into useful compression through the provision of a spiral casing around the fan, in which the air whirled off by the blades of the fan is deflected and conducted into a discharge pipe leading off from the casing. The blower therefore consists of a fan with radial or sometimes curved blades which stand parallel to the



Disc Wheel.

axis instead of obliquely as in the case of the disc fan, and which revolve in a circular or spiral casing surrounding the fan and opening into a large discharge pipe that leads off at a tangent in any desired direction—up, down, or sideways. Air enters around the shaft of the fan through openings in the center of the casing, and, being received by the blades, is whirled around and thrown outward into the surrounding chamber with a pressure proportionate to the square of the speed of the fan. The pressure thus produced is sufficient for blowing fires of all kinds, for removing small fragments of wood as well as finer particles from wood-cutting machines, for delivering illuminating gas to holders, and for other purposes requiring a pressure of not much over one pound per square inch. The centrifugal blower is the most efficient contrivance known for producing these pressures, but its economy falls off very fast if the speed is made so great as to produce a pressure per square inch of much over one pound.

This machine seems peculiar in its behavior owing to the fact that it requires less power to maintain a certain speed when the discharge passage is partly closed than when it is fully open. It is evident that when there is no discharge opening, the fan, together with the air between its blades, will spin around freely like any wheel. If the discharge gate be opened, air will flow about the fan blades to their outer ends, and so into the casing and thence to the pipe system; while air from the center of the fan follows out into the space between the blades, its speed increasing as it approaches the ends of the blades, whereupon it is hurled into the casing. It is the work done in accelerating the motion



CROSS-SECTION OF POSITIVE PRESSURE BLOWER.

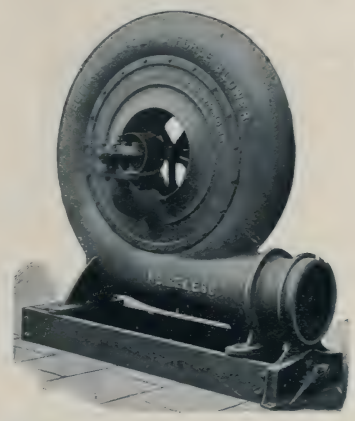
AIR-COMPRESSOR.

of these particles of air, which explains the resistance to the movement of the fan; and this work is evidently in proportion to the quantity of air that passes along the fan blades, being zero when, by reason of the closing of either suction or discharge opening, no air is discharged, and being greatest when, with full opening, the volume of air passing is the maximum. The blades of the blower would fly in pieces before the speed could be increased sufficiently to produce an air pressure much over one pound per square inch.

An apparatus identical in principle is the centrifugal pump, which, handling far heavier fluids, produces by centrifugal action pressures measured by pounds instead of ounces.

The Positive Blower

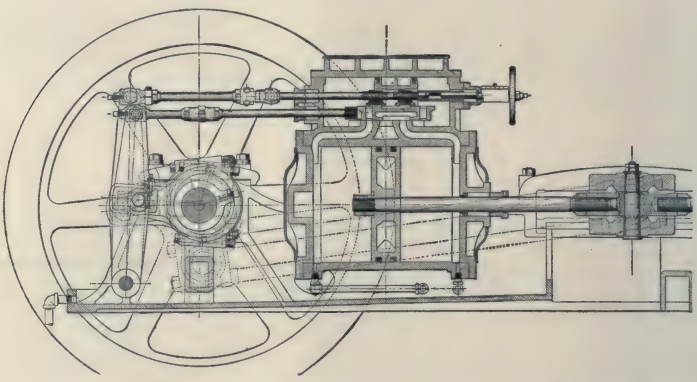
In direct competition with the centrifugal fan is the positive blower. Consider a fan having opposite blades, revolving in a closed casing, and carrying around with it the air confined between the blades. If a radial partition could be slipped in just after one of the blades had passed, the following blade would compress the air between it and the partition, and would force it out through a discharge pipe if one were provided near the supposed partition. This partition might be imagined to be momentarily withdrawn as each blade passed, so that successive portions of air would be trapped and compressed. The positive blower consists of a fan of this sort, with one or more blades, revolving in connection with an "abutment" performing the office of the partition just alluded to. A well-known form consists of a cylinder carrying two radial blades, and revolving in contact with a cylinder of half the diameter which is provided with a gap of proper form to receive the passing blades. As each blade travels around the casing, it drives the air before it up to the smaller cylinder, whose gap comes around at the proper instant to allow the blade to pass, while intercepting the air continuously.



STEEL PRESSURE BLOWER.

The faults of these blowers are two—

namely, weight and leakage. The cylinders, blades, and casing—which, on account of their peculiar shapes and accurate fitting, are almost necessarily made of cast iron—are excessively heavy for use in connection with air at low pressures, while pressures sufficient to utilize the full strength of the apparatus could not be attained because of the excessive leakage that would occur along the loose rolling contact of blades and abutment, and between blade and casing after a little wear had occurred. The mass of the moving parts, contrasted with the lightness of the working fluid, suggests the clumsiness of using a two-inch plank for a palm-leaf fan. The positive blower, limited to moderate speed by the noise and shocks of the heavy members of the apparatus, can produce pressures but little greater than those obtainable by means of the centrifugal blower.



SECTIONAL VIEW OF STEAM CYLINDER OF A TYPICAL AIR-COMPRESSOR.

The Air-Compressing Engine

The air-compressor proper is a cylinder-and-piston machine like the common steam engine. It comprises two sets of valves, usually designed to be opened automatically by excess of pressure under them and to be closed by gravity or by the action of springs when the pressures become equal. The inlet valves open just after the piston commences its stroke, when the expansion of the compressed air remaining in the cylinder behind the piston has lowered the pressure above the valves. They close at the end of the intake stroke, just as the piston comes to rest. The outlet valves lift during the compression stroke, at about the time the rising pressure in the cylinder becomes equal to that in the outlet passage above the valves; and they close when the flow of air ceases as the piston completes its stroke.

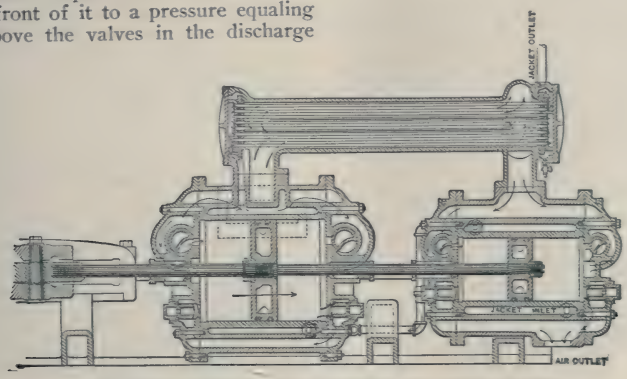
Perfectly correct action of automatic valves is not realized in practice. The valve must evidently be larger than the opening in its seat, so that the upper surface is larger than the area underneath reached by the lower pressure; consequently the valve will not open until the pressure below is greater than that above. To prevent destructive slamming of the valves, springs must be provided to force them to their seats just as the flow ceases and before the reverse stroke of the piston can cause much backward flow of air. The pressure of the springs acts to choke the flow through the valves, increasing the resistance they offer to the passage of air. Large compressors are therefore often provided with mechanically-actuated valves which are opened and closed smoothly at the proper moment by eccentrics and valve rods. Any of the steam-engine valve gears may be used for compressors, and designed by the same methods, observing only that the compressor is in every way a reversed steam engine, so that its discharge port and valves are duplicates of the

inlet details of the engine, while the engine exhaust and the compressor inlet valves are also similarly related.

Varying initial (or boiler) pressure is compensated, except in throttling engines, by varying time of inlet-valve closure or "cut-off;" and varying discharge pressure in a compressor calls for variation in time of opening of the discharge valves. In both cases, the means of variation constitute the chief problem for the designer.

Mechanically-moved inlet valves of compressors act always at the same points, opening a trifle after the piston starts on the intake stroke, and closing exactly at the end of the same stroke; but the discharge valves must open at the instant the piston has compressed the air in front of it to a pressure equaling that above the valves in the discharge pipe, and must close always at the same instant, at the end of the stroke. As the compressor may be working against a pressure greater or less than that regularly carried, the discharge valves must be so controlled as to open at whatever point is required by the pressure then being carried. The requirements are sometimes met by putting automatic lift-valves above, or even directly upon, the mechanical discharge valves, giving the combination the effect of valves automatic as regards their opening, but positively closed by the mechanism at the proper instant. Such lift-valves, being shut off entirely at the proper closing instant, seat themselves without noise or shock, and may therefore have very light springs, causing less resistance to the air passing through.

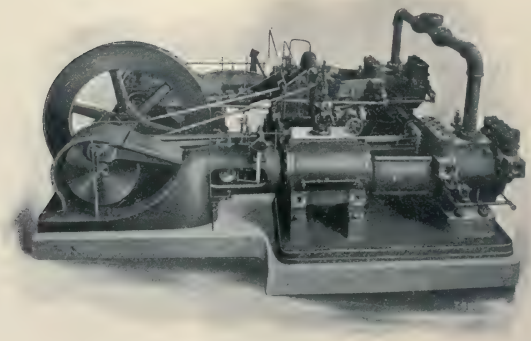
Where the expense of full mechanical action is warranted on account of the superior efficiency obtainable, poppet or rotary valves may be arranged to open by means of springs or air dashpots. The opening device is released either through the rising pressure in the cylinder easing the valve on its seat, and reducing the friction until the valve, when balanced, slips freely open; or through the same pressure acting on a piston attached to a pusher, the operation of which results either in starting the valve in spite of friction or in lifting a catch and thereby freeing the spring or dashpot mechanism of the compressor.



SECTIONAL VIEW OF AIR CYLINDERS AND INTER-COOLER.

Compound Compressors

While low-compression pressures are accompanied by only moderate heating of the air during compression, the production of high pressures is attended with excessive heat and considerable increase in the volume of the compressed air. As the air leaving the cylinder soon resumes the normal temperature, and decreases in volume accordingly, the extra work done in compressing the increased volume is wasted. Compressing cylinders in operation are always cooled by water or otherwise; but it is impossible, even by spraying water into the cylinder, to keep the air from rising considerably in temperature. For high pressures, resort is therefore had to com-



CROSS-COMPOUND-DUPLEX AIR-COMPRESSOR.

pound compression, the air being passed successively through larger low-pressure to smaller high-pressure cylinders, between which are located inter-coolers whose function is to restore the air to its original temperature before it enters on the next stage. The volume of the air is thus kept as small as possible; and the successive stages of compression result in producing the required pressure, with a minimum of loss from heating during the process. Two-stage machines are preferred to single-stage where air must be compressed to one-sixth or a smaller fraction of its volume at atmospheric pressure (measuring pressures from absolute vacuum); and three or more stages are required in compressing to one-sixth or less. Cylinder diameters are selected which will provide for about the same amount of work being done in each cylinder.

Most compressor problems deal with air taken directly from the atmosphere at its sea-level pressure; but, as at moderate elevation there is a marked decrease of the atmospheric pressure, compressors for high locations must deal with air at pressures below fifteen pounds absolute. Under such conditions the volume of air taken into the compressor at each stroke weighs less, and therefore less air is delivered by the compressor, while there is a corresponding decrease in the power to run the machine. The ratio of compression, and the rise in temperature, are proportionately increased, so that a two-stage compressor may be desirable for pressures that would call for only single cylinders at sea-level. Thus, at many of the mines in the Rocky Mountain region, the atmospheric pressure is as low as eleven pounds per square inch, so that 90 pounds' air pressure by gauge requires a compression ratio of nine to one, which is considerably beyond that proper for a single-stage compressor. In general, high-level compressors should be specially proportioned for their work.

Methods of Driving

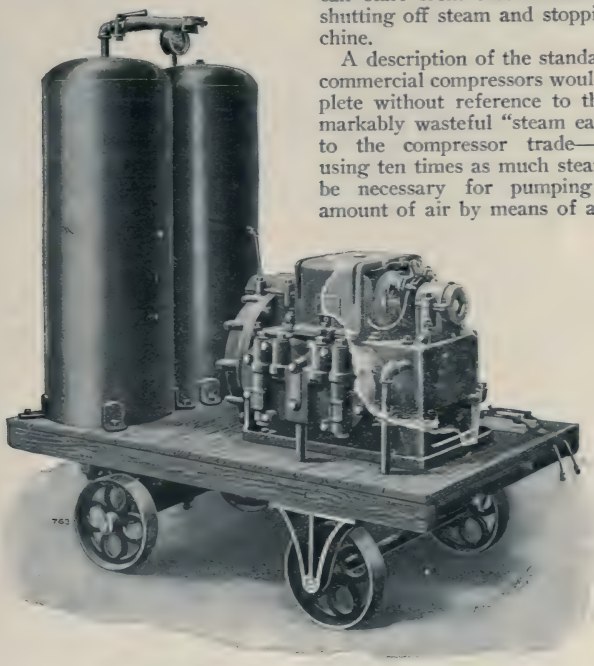
Like pumps and other machinery, compressors are direct-connected to engines or are driven through gears or belts from separate sources of power. The reciprocating piston compressor requires a varying effort to balance the cylinder pressure, since, during the stroke, the piston moves against an increasing air pressure, and finally against the full discharge pressure, in pushing out the contents of the cylinder. Direct-connected compressors are either "straight-line" (tandem), having steam and air pistons on the same piston rod, or they are connected to cranks set at an angle on a common shaft. The first method reduces floor space and cost, but requires very heavy fly wheels, and makes the machine liable to stop on a center if run much below full speed and capacity.

It is evident that steam used expansively supplies against the piston a force decreasing toward the end of the stroke,

while air during compression opposes a force increasing towards the end of the stroke; thus the power rapidly falls off as the resistance increases, causing a perceptible reduction in speed at the end of each stroke. If such a machine could be run at high speed, the weight (or more correctly, the mass) of the pistons and connections would, by inertia, help out the decreasing steam pressure when slowing to pass the centers, and thus produce a more even effort on the crank; but sufficiently high speeds are not possible for the automatic-lift valves generally used on small compressors. The varying power and resistance can be very satisfactorily balanced by connecting steam and compressing pistons to separate cranks set at right angles. Having provided two frames and cranks, a slight additional outlay will supply an extra pair of cylinders tandem to the first pair, making a full duplex compressor. The excess steam pressure at the commencement of the stroke of one side is here transmitted by the crank shaft to the other side of the machine, to help out the deficient pressure of the expanded steam when the stroke is nearly finished. Such a machine has no "dead centers," and can be run at very slow speed when necessary.

As it is generally desirable to maintain a constant air pressure, and to vary the speed of the machine according to the quantity of air required, speed governors for the steam cylinders are not needed except to prevent racing in case of a bursting pipe or other excessive discharge of air. Some form of adjustable cut-off valves is very desirable in order to allow of suiting the work of the steam cylinder to the load. The pressure is controlled by automatic devices actuated by the rise and fall of the air pressure, either shutting off the air intake, opening a by-pass around the compressor piston, or (in case of duplex machines which can start from rest without attention) shutting off steam and stopping the machine.

A description of the standard types of commercial compressors would be incomplete without reference to the most remarkably wasteful "steam eater" known to the compressor trade—a machine using ten times as much steam as would be necessary for pumping the same amount of air by means of a fairly eco-



PORTABLE TYPE OF MOTOR-DRIVEN COMPRESSOR.

nomical compressor, and yet a device most ingenious and entirely satisfactory for its work. This is the air-brake pump, which, for actual conditions of train service—where it stands idle until the closing of the throttle and the application of brakes leave a large and heavily fired steam boiler to blow off at the safety valve until the fire can be checked—is seen to be well adapted. Indicator cards show that the entering steam is throttled through about half the stroke, while the exhaust is similarly choked at first and only let out freely about the time of full opening of the valve. The result is a "straight-line" compressor having no crank or fly wheel, with nothing moving but its two pistons and one rod, and yet so perfectly balanced between effort and resistance that its strokes are smoothly made at any speed from slowest to fastest, and all with maximum simplicity and minimum weight. These machines are also built with compound steam and two-stage air cylinders, and in these cases have pressures in the cylinders so nearly uniform that the steam distribution may be considerably more economical than it is possible to obtain in the single-stage compressor.

The selection of general types and special details for compressors must be based, as in all other cases of machine design, on the practical condition of getting the best return from the money invested, with due regard to the importance of reliability and durability in each particular case.

Why Do We Wait?

WHY do we wait till ears are deaf
Before we speak our kindly word,
And only utter loving praise
When not a whisper can be heard?

Why do we wait till hands are laid,
Close-folded, pulseless, ere we place
Within them roses sweet and rare,
And lilies in their flawless grace?

Why do we wait till eyes are sealed
To light and love in death's deep trance—
Dear, wistful eyes—before we bend
Above them with impassioned glance?

Why do we wait till hearts are still
To tell them all the love in ours,
And give them such late meed of praise,
And lay before them fragrant flowers?

How oft we, careless, wait till life's
Sweet opportunities are past,
And break our "alabaster box
Of ointment" at the very last!

Oh, let us heed the living friend
Who walks with us life's common ways,
Watching our eyes for look of love,
And hungering for a word of praise!

—*British Weekly.*

Improved Locomotives

The Vauclain Balanced-Compound Engine

By WINTHROP PACKARD

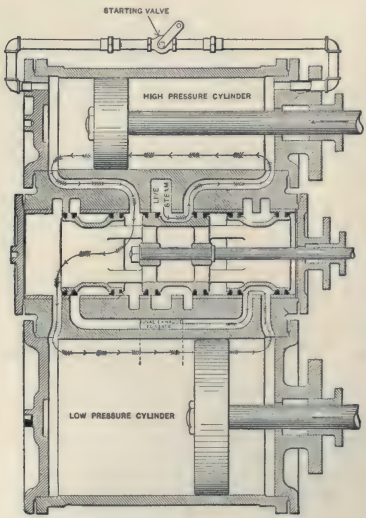
THE factors of chief importance in determining the practical value of a locomotive are its hauling power, speed, cost of running, endurance, and wear on the track. All these points are, of course, carefully considered by the designer who aims to build a locomotive having the highest possible coefficient of serviceableness. Experienced engineers have found it comparatively easy to construct a locomotive which can draw six or eight cars over a well-built track at the rate of seventy or eighty miles an hour; but the problem of reducing the amount of fuel consumed, and of lessening the strain on the rails caused by the vertical shock of the rotating weights in the driving wheels, without sacrificing either speed or power, has proved much more difficult.

VAUCLAIN BALANCED-COMPOUND LOCOMOTIVE.

Of the many attempts made to solve this difficulty, undoubtedly one of the most successful so far has been that of S. M. Vauclain, who two years ago designed a locomotive to which the name of the Vauclain Balanced-Compound was given. Since then, several of these engines have been built by the Baldwin Locomotive Works, and have been used on a few railroads in the West with most satisfactory results.

Careful tests have proved that these locomotives can haul larger loads, in faster time, at less expense, than any other type. Specifically, the Vauclain compound uses 25 to 40 per cent less fuel, and 20 per cent less water, than the ordinary engine. Its chief point of superiority, however, is in the maintenance of track. In all two-cylinder locomotives, whether single-expansion or compound, and in four-cylinder types such as the tandem and the original Vauclain compound, the reciprocating parts are counterbalanced by rotating weights in the driving wheels. This arrangement of balance becomes unsatisfactory, particularly for heavy locomotives and in cases where extremely high speeds are attained. By balancing their reciprocating parts against one another, the rotating balance in the wheels used to complement these parts can be eliminated, avoiding to a great extent the vertical shocks, and reducing the strain upon the track to that directly due to the weight of the locomotive. Consequently, with a self-balanced arrangement of reciprocating parts, the weight on the driving

wheels may be increased without damaging the track, and higher speed is attainable without undue strain upon the working parts of the locomotive. The balanced-compound engine is intended to accomplish these results, and to simplify, as far as possible, the arrangement of the working parts.



STEAM DISTRIBUTION IN BALANCED-COMPOUND CYLINDER.

The cylinders are a development of the original Vauclain four-cylinder compound type, with one piston slide-valve common to each pair. Instead of being superimposed and located outside of the locomotive frames, the cylinders are placed horizontally in line with one another, the low-pressure outside and the high-pressure inside the frames. The slide-valves are of the piston type, placed above and between the two cylinders which they are arranged to control. A separate set of guides and connections is required for each cylinder. The two high-pressure cylinders being placed inside the frames, the pistons are necessarily coupled to a crank axle. The low-pressure pistons are coupled to crank pins on the outside of the driving wheels. The cranks on the axle are set at 90 degrees with each other, and at 180 degrees with the corresponding crank pins in the wheels. The pistons, therefore, travel in the opposite direction; and the reciprocating parts act against and balance one another to the extent of their corresponding weight.

The distribution of steam is shown in the accompanying diagram. The live steam port in this design is centrally located between the induction parts of the high-pressure cylinder. Steam enters the high-pressure cylinder through the steam port and the central external cavity in the valve. The exhaust from the high-pressure cylinder takes place through the opposite steam port to the interior of the valve, which acts as a receiver. The outer edges of the valves control the admission of steam to the low-pressure cylinder. The steam passes from the front of the high-pressure cylinder, through the valve, to the front of the low-pressure cylinder, or from the back of the high-pressure to the back of the low-pressure cylinder. The exhaust from the low-pressure cylinder takes place through the external cavities under the front and back portions of the valve, which communicates with the final exhaust port. The starting valve connects the two live steam ports of the high-pressure cylinder, to allow the steam to pass over the piston.

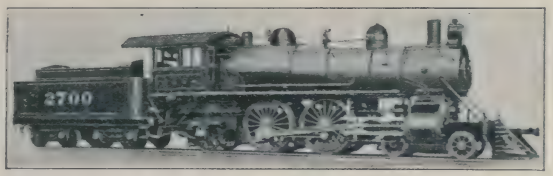
The dimensions of the high-pressure cylinder are 15 by 26 inches; and of the low-pressure, 25 by 26 inches. The working pressure is 200 lbs. The fire-box has a heating surface of 168.5 square feet; and the grate, one of 34.69 square feet. The rigid wheel-base is 13 feet 6 inches, and the total length of the engine 27 feet 5 inches. The total weight of the locomotive is 160,000 lbs. Its water capacity is 5,500 gallons, and the tender holds 10.5 tons of coal.

As an illustration of the superiority of the new Vauclain engine over other types in common use, two recent trial runs may be cited. These took place on the line of the Chicago, Burlington & Quincy from McCook to Akron, Col., a distance of 143 miles, including an elevation of 2,150 feet. A Vauclain balanced-compound locomotive drew the mail train of ten cars weighing 664 tons these 143 miles in 2 hours 56 minutes, at an aver-

age speed of 48.6 miles an hour, reaching at times a velocity of 68 miles an hour. The usual time made by the mail train drawn by single-expansion locomotives from 17,000 to 35,000 lbs. heavier than the Vauclain, was 3 hours 36 minutes. On a second run over the same division with a train of twelve cars, the Vauclain made an average speed of 42.46 miles an hour, which was thirteen minutes faster than the heavier locomotive carrying only eight cars could make. On these trials the Vauclain engine burned, each trip, 32 per cent less coal and used 20 per cent less water than the others.

The managements of several of the large Western roads have been quick to perceive the great advantage of the new locomotive; and nearly 100 of them are now in use on the tracks of the Burlington, Santa Fé, and other systems. In the East, the New York, New Haven & Hartford Railroad is the only road thus far to adopt the new engine. They have ordered twenty, two of which have been received and are already in daily operation. On the trial trip between New Haven and Boston, November 12, 1904, a new Vauclain locomotive broke the record by 19 minutes, making the run of 160 miles, including three stops, in 2 hours 55 minutes. It is not unreasonable to prophesy that when the railway company shall have completed its new bridges at Coscob, Bridgeport, and Westport, it will be possible to make the run from New York to Boston in a little over four hours, representing a saving of from 40 to 50 minutes over the fastest time now made by the special limited expresses. One of the new Vauclain engines could, if necessary, haul the train the entire distance without having to re-coal on the way.

It may be gathered, then, from the facts thus briefly set forth, that the Vauclain balanced-compound locomotive seems destined to work a revolution along the lines of freight and passenger traffic by increasing greatly the speed and power of locomotion, as well as very appreciably lessening the expense for fuel and maintenance of track.



Dinner-Pail Philosophy

¶ The spirit that does not soar will often grovel.

¶ The man who owns a gold mine is a fool not to work it.

¶ Cheerfulness and perseverance are nine-tenths of success.

¶ Sense, sincerity, simplicity—the "Three Graces" of the gentleman.

¶ The man of real nerve is the man who can keep his mouth shut, but is always there when needed.

¶ Respect every man's opinion, but act on your own.

¶ Follow suit on good leads—throw off on the bad ones.

¶ A man never has to go half-way in order to meet trouble.

¶ Gold is found in the bed of the stream, not floating along with the ripples of its surface.

¶ The first requisite of a good citizen in this Republic of ours is that he shall be able and willing to pull his weight.

The Technical World

Published Monthly by the

TECHNICAL WORLD COMPANY

3321 Armour Ave., Chicago, Ill., U. S. A.

EDITORS { ALFRED S. JOHNSON, PH. D.
ALFRED E. ZAFF, S. B.
GEORGE R. METCALFE, S. B.

SUBSCRIPTIONS

United States, Canada, and Mexico $2 per year
Foreign Countries . . . . . $3 per year

¶Remit by Draft on Chicago, Express or Postoffice Money Order, payable to THE TECHNICAL WORLD COMPANY.

¶Subscriptions will begin with current issue.

¶Changes of address should reach the publishers two weeks in advance of date of issue.

¶Entered at the Postoffice, Chicago, Illinois, as second-class mail matter.

Advertising Rates on Application

¶Copy for Advertisements must be received by the 25th of the preceding month.

Illustrated articles on topics of timely interest are solicited for publication. Those that are *short* and *accompanied with good photographs* will receive special attention. Accepted articles will be paid for at regular space rates.

¶ Don't loaf.

¶ Look for good, not evil.

¶ Keep your eyes open and your mouth shut.

¶ Do just as much as you can do well, no more.

¶ A man who never makes mistakes never makes anything else.

¶ You will never *find* time for anything—if you want time, you must make it.

¶ Take pride in the hard, consistent, straightforward, and uncompromising effort which has been stamped as "the strenuous life."

¶ You cannot prevent the birds of the air from flying over your head, but you can prevent them from building their nests in your hair.

¶ Make your own opportunities.

¶ Gloom is never dispersed by growling.

¶ Some prize winners are long-distance runners.

¶ Live in the present with a watchful eye on the future.

¶ Trouble postponed always has to be met with accrued interest.

¶ Some men would rather sleep an hour later than wake up and find themselves famous.

¶ The very effort to advance—to arrive at a higher standard of character than we have reached—is inspiring and invigorating; and, even though we may fall short of it, we cannot fail to be improved by every honest effort made in an upward direction.

Electrification of a Steam Railroad

ELSEWHERE in this issue will be found an interesting description of the remodeling of the Grand Central terminal in New York City, which, when completed according to the plans outlined, will undoubtedly be one of the most important and best equipped of railroad terminals ever built. It is also of interest to note that in connection with this great engineering work electricity is to be one of the most important factors. Electric locomotives will be used exclusively for the operation of all suburban trains, and for a distance of 34 miles on the main line of the New York Central & Hudson River Railroad and 24 miles on the Harlem division of this road.

The fact that trains have hitherto entered New York City through a long tunnel, is one of the strongest arguments for the use of electrical propulsion, as there is to-day a growing feeling among engineers that electric power is the only safe power to use in tunnels or subways. Where ventilation is not very

thorough, the fumes from steam locomotives endanger the lives of passengers, while escaping steam has caused serious accidents by obscuring signals.

The first of the new electric locomotives built for this service was given an official trial a few weeks ago. It has four driving axles, each of which carries the armature of an electric motor mounted directly upon it; and the motors have a normal rating of 550 horse-power. This makes the total rated capacity of the locomotive 2,200 horse-power, although for short periods it is capable of developing considerably greater power than this. It is of interest to note that this is more powerful than the largest steam locomotive in existence.

The heaviest trains which are to be handled by electric locomotives weigh 875 tons, and are drawn at a maximum speed of from 60 to 65 miles per hour. For hauling these heaviest trains, two locomotives are coupled together; and, when so coupled, the method of electrical control is such that they can be operated by a single crew from either locomotive, only one controller being used to actuate all the motors on both locomotives.

On the trial trip a maximum speed of 63 miles per hour was attained with an eight-car train; and with a four-car train, 72 miles per hour was reached. Both of the trains were still accelerating at these speeds, but the length of the track electrically equipped did not permit of reaching higher speeds.

The electrical system which is being adopted by the New York Central is, however, applicable only for terminal purposes or over limited distances, as the low voltage of the current used entails a cost for electrical conductors and sub-stations along the line of the road which would be prohibitive if extended over great distances. But the fact of electricity being used in such heavy and severe service is no small triumph of electrical engineering; and it is not improbable that the experience of steam railroad men with this flexible, powerful, and cleanly motive power may pave the way for the adoption of high-tension alternating current systems which will be able to operate economically over very long distances.

Growing Use of Steam Turbines

TWO years ago the steam turbine was hardly considered in connection with large power plants, although this was one of the earliest suggested forms of steam engines. Turbines of the Parsons type, having an extremely high velocity of rotation, and using gearing to reduce this to practicable speeds, have been in use for some time to a limited extent, for special applications; but, within a comparatively few months, turbines having several stages and operating at comparatively low speeds have been perfected and introduced to such an extent that they have already brought about considerable modification in the design and arrangement of steam plants.

One of the most noticeable features in a turbine plant is the relative size of the turbines and reciprocating engines of the same capacity. The floor space occupied by a large cross-compound engine would be sufficient for three or four times its capacity in turbines, and this saving in space means considerable in the case of plants located at cities where real estate is very valuable.

Another modification due to turbines is the very noticeable increase in the pressure and temperature of the steam. From 150 to 200 pounds' pressure, and from 100 to 200 degrees of superheat, are frequently used in connection with steam turbines; and much higher vacua are also generally employed, as the economy of high vacua is more marked in the case of the turbine than in that of the reciprocating engine. The efficiency of the steam turbine is somewhat higher than the average efficiency of steam engines, although a multiple-expansion reciprocating engine of European make has been tested under high vacuum and extremely high superheat, which showed a higher efficiency than the turbine has yet reached. Where average working conditions are found, however, the turbine undoubtedly has some advantage in the matter of efficiency.

Aside from high efficiency, the turbine has many points to recommend it, among which may be mentioned the absence of reciprocating parts, the absolute uni-

formity of turning moment throughout an entire revolution, the ease and simplicity of repair, the absence of all bearing surfaces, except the two main journals, and immunity from accident by reason of water being carried over with the steam. Its overload capacity is also very large, and its economy under varying loads very marked. These points of advantage have been sufficient within a very short time to make the steam turbine a formidable rival of the highest grades of reciprocating engines on the market.

Compressed Air

THE vast number of applications of compressed air to modern engineering problems have proved it to be one of the most flexible and efficient agents for the transmission of power over comparatively short distances; and when its advantages come to be more generally appreciated, its use will be extended to many of the operations of everyday life. In view of its rapidly growing field of usefulness, the description of various forms of air-compressors, which will be found elsewhere in these pages, is of timely interest. Owing to the wide variations of air pressure required for different services—which range from a few ounces' to several hundred pounds' pressure per square inch—a number of different types of compressors have been developed. With the fan and blower types, whose limits of economical operation are within one pound pressure, few difficulties are found in the construction of the compressing machinery, which is extremely simple.

As the pressures increase, however, the machines become more and more complicated, owing not only to the greater power required, but also to the heating of the air during compression. The dissipation of heat, is in fact, one of the most difficult problems with which the designer of air-compressors has to contend. The use of water-jackets for cooling the air in the compression cylinders is general, but this does not effect thorough cooling, as only a small portion of the air in the cylinder comes in contact with the jacketed parts. This difficulty has led to the use of compound machines, in which case inter-coolers are generally used between the different stages of compression, which cause the air to shrink in volume between the stages. A properly designed inter-cooler should reduce the air in the cylinders to the temperature of the outside air. The economy of compressing in several stages—or, in other words, compound compressors—is shown from the fact that in compressing air up to 100 lbs. the heat loss reaches about 30 per cent. By compressing in two stages, this loss is cut down to less than half; and in four stages, it is reduced to four or five per cent. It is evident, therefore, that the higher the pressure required the more essential is the use of compound machines. It is probable that much of the delay in the adoption of compressed air for numerous purposes has been caused by the complicated and ponderous machinery formerly used; but this objection is rapidly disappearing with the introduction of simple, durable machinery which can be readily operated by entirely unskilled attendants.

Training Sailors Technically

THE old-time able seaman had to know how to "hand, reef, and steer." Such, nominally, is the requirement of the able seaman of the navy of to-day, though in practice he has neither to hand nor reef, and the ship steers by a mechanical gear which responds to the touch of a finger even in the heaviest seas. The sailor who would rise above the ordinary to-day, must have technical training. Seamen for our increasing Navy are none too plentiful, and those who come to it with technical training are few indeed; so the Government is taking the matter in hand and giving it to them after they arrive. The United States Navy is establishing the most thorough system of wireless communication in the world, and to operate this it must have many wireless operators. At present a corps of twenty-five sailors is being trained in these mysteries at the Brooklyn Navy Yard. It takes three months to make a wireless operator out of the average sailor from the warships; and as soon as he is made,

he is turned over to one of the various stations far or near, to begin active service at a salary increasing as he shows efficiency and is promoted. The ordinary seamen recruits receive but $16 per month, but the wireless man when graduated is rated as a third-class electrician at $30 per month. From that, advancement brings rapid increase up to the position of Chief Electrician at $70 per month. The Bureau of Equipment is preparing to establish a network of wireless stations covering the entire coast of the United States from Key West in Florida to Alaska and the Aleutian Islands in the north, and extending to Honolulu, The Philippines and the Panama Canal strip. When you add to this the fact that every warship in our great and growing Navy is equipped with similar apparatus and must hence carry two or more operators, it will be seen that the chance for electrically trained young men in the Navy is a good one. The modern battleship is no longer a fine sailing ship equipped with guns, but a huge and complicated floating mechanism requiring scores of highly trained men to make her efficient. In this fact lies the hope of advancement for the man who enters the service already equipped with a good mechanical training.

Natural Gas Again

NATURAL gas, not such as bubbles from political orators, but the kind which flows from the depths of the earth, is again coming into constant and increasing use, because the supply is once more to be depended on. When this great source of light, heat, and power from the chasms of the earth was first discovered, it was used with reckless extravagance. The cities and towns near the wells received it at merely nominal rates, and acted as if they knew the supply was exhaustless. Dooryards were lighted by it at night, and it was burnt in countless ways for the fun of the thing. Great industries were built up dependent on its use; and when the supply, as might have been expected, began to decline, suffered from the lack of it. The supply ran low and lower, and gas was regarded as a declining product, likely to pass away almost entirely. But a lesson was learned from this prodigality, and the safeguarding of the much reduced supply began. During the last few years new wells have been struck, and, the lesson having been learned, the industry seems to be once more on a prosperous basis. The supply is virtually confined to four States—Pennsylvania, West Virginia, Indiana, and Ohio. Last year's output from these States was the most valuable since the first wells were sunk. In round figures it represented nearly $36,000,000. The volume at atmospheric pressure was 238,769,067,000 cubic feet, and its heating value was estimated as equal to that of 11,938,453 tons of bituminous coal.

Valuable Invention Lost?

THE fact that "dead men tell no tales" has lately caused much uneasiness in the scientific world, for two men who recently died are feared to have taken with them a secret of great importance. In certain classes of spectroscopic work, a concave mirror is used on which are engraved parallel lines, sometimes 100,000 to the inch. Professor Rowland of Johns Hopkins University, a scientist of splendid mechanical ability, invented a machine for making these lines. Its principal mechanism was a screw with an exceedingly fine thread that had to be cut and ground under water by a method hitherto unknown, which the professor taught only to his head mechanic. These two men alone held this priceless secret for years, and ground out the machines regularly for the whole world, but did not grind out the secret with them. Then one day Schneider, the head machinist, died. Professor Rowland at once set to work teaching the secret to another foreman; but before it was accomplished, Rowland himself died.

Is the secret lost? It remains to be seen. Attempts have lately been made to cut a new screw like those cut by Schneider and Professor Rowland, and the scientific world is waiting the result with great interest. If it fails, the three machines already in working order will be priceless.

WHERE HISTORY

CANOPY OVER PLYMOUTH ROCK.

THE ROCK ITSELF.

On this rock, tradition tells us, the Pilgrims from the "Mayflower" landed, December 21, 1620. Although its reclining place is in the little Massachusetts town whose name it bears, Plymouth Rock underlies all America. On it Putnam stood when at Bunker Hill he shouted, "Don't fire till you see the whites of their eyes;" and Jefferson had it for a writing-desk when he drafted the Declaration of Independence.

LINE OF THE MINUTE MEN
APRIL 19
1775
STAND YOUR GROUND
DONT FIRE UNLESS FIRED UPON
BUT IF THEY MEAN TO HAVE A WAR
LET IT BEGIN HERE

CAPTAIN PARKER BOULDER, ON THE BATTLEFIELD OF LEXINGTON.

This boulder marks the line of the Minute Men. The old musket, with powder horn thrown over it, points in the direction of the line of battle. In the background is the Harrington House, previously described.

A LYRIC OF THE SNOWS.

This picture was intended to convey an impression of sound by means of the lines and tonalities afforded by the subject. The long curve of the foreground—the melody of the song—is endlessly repeated and embellished by the parallel series of darks which stand for the "grace notes" of music. The harmony is completed by the lower tones of the middle distance. A simple but forceful arrangement.

Principles of Artistic Photography

How to Get the Best Results

First Paper*

By LOUIS A. LAMB
Editor *Pit and Post*

GRAPHIC language is universal. Hence, among the means of educational grace, photography may claim premiership. The advance of general intelligence during the last thirty or forty years is due very largely to the invention of the gelatine dry plate by Dr. Maddox, and the invention of the half-tone process of engraving by Baron von Egloffstein, resulting in the world-circling conquest of the hand camera and the globe-girdling triumph of the illustrated print.

Coming at once to the subject in hand, it is undoubtedly true that the technologist of the future will more and more have recourse to the process of photography, even though the camera may not supplant the slide rule and logarithms. Certainly there is to-day no branch of technics which does not owe much to the camera—witness the new art of photo-topographical surveying, microphotographic metallurgy, photographic designing and applied art; the use of photography in agriculture, in anthropology, in forestry, in war, in ballistics, in thermometry, and in the graphic study of high-speed dynamics. It is ardently desired that these papers may suggest to the student of technology many useful applications of the camera to all branches of practical, applied science and the fine arts.

Fortunately there is no longer the early temptation to empiricism which so vitally impairs the usefulness of many treatises on photography. The incanta-

THE PLACID POOL.
Analysis of this simple picture will show that it is perfectly contained in an "evolute" beginning with the curved gunwale of the sunken boat and following the shore line—the curve being repeated by the main outline of the foliage. The obvious repose of the subject is largely due to the nature of the curve on which it is built up.

*NOTE.—The next paper will deal with some of the difficulties encountered by the novice.

A STUDY IN PEARL GRAYS.

This photograph was made without a lens, through a needle-hole five-thousandths of an inch in diameter, with an exposure of 17 seconds. It illustrates the fact that "needle-hole" photography is unexcelled where natural perspective and fine atmospheric effects are especially desired.

tion period has passed away, and the mystery which once invested the craft of the camera has been entirely dispelled. It is now a matter of pure science and fine art.

In the first place, any camera and any lens may be made to serve a wide and useful range of applications. Even a small aperture in black paper will serve well for a lens, some workers preferring a pin-hole for pictorial photography. The rule is, of course—*Use the best apparatus that you can afford.* There is no virtue in affecting poor instruments.

PURPLE AND GOLD.

In this picture the problem obviously was to preserve the values of the distance and to suggest the hazy atmosphere of an autumn afternoon. By using a long-focus lens, focused sharply on the immediate foreground, the planes of the distance and middle distance were differentiated perfectly, and the desired impression thereby obtained. Notice also the pleasing disposition of masses throughout the subject, and the unobtrusive but interesting detail everywhere.

IN THE OGUNQUIT WOODS, MAINE.

This print specially illustrates the successful handling of a problem of repeating vertical lines under difficult conditions of lighting. Observe the grouping of subordinate lines on the right and left, so as to balance the composition; and note the enhanced beauty and effectiveness of the central foliage mass by the contrast of the highest lights and darkest shades.

Focal Length of Lens

It is unnecessary to repeat the words of elementary textbooks, that the camera is merely a dark box provided with a light-converging system and with means for inserting a sensitive plate in the plane of the image. Reserving for later discussion the particulars about the various parts of the camerist's outfit, it will suffice here to say that the *focal length* of the lens—the distance from its effective aperture at which parallel rays are made to meet in a point or disc of light—is the most vital single fact to be known about it, since focal length largely determines the utility and value of the objective. It absolutely determines the kind of camera with which the lens may be used, as the following illustration will show:

A lens of 2½ inches' focal length treats all rays emanating from luminous objects 30 feet or more distant, as if they were parallel and projected from infinity, every object beyond being sensibly in sharp focus when the maximum definition of image has been obtained for the 30-foot object. This is the quality called "depth of focus;" and lenses possessing it may be used in cameras of fixed extension. But if a lens of 24 inches' focus be employed at the same relative aperture, it will be impossible to have sensibly sharp definition at the same instant, of several objects at different distances within one-half mile of the camera. To do this, the aperture must be reduced, making the lens much slower.

Moreover, focal length is one term of the ratio involving "effective aperture," upon which, almost entirely, depends the working speed of the lens, and consequently its adaptability for a variety of valuable uses. Since at best only one eighty-thousandth of the luminous rays from a reflecting object can enter the lens, it is obvious that the focal-aperture

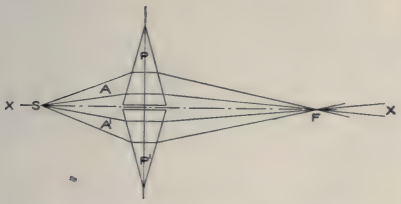
THE SHAW MEMORIAL, BOSTON, MASS.—BY ST. GAUDENS.

When Augustus St. Gaudens wrought this masterpiece, he had in mind as an essential part of his conception a certain accessory scheme of landscape art. This fine photograph does what most pictures fail to do—gives us the gem in its harmonious and necessary setting. Observe how greatly the drama of the bronze is heightened by the massive tree trunks, and by a score of symbols drawn from the accessories.

ratio should be as great as possible without impairing the performance of the objective; but every decrease of the aperture for the sake of depth of focus, geometrically diminishes its light-gathering and transmitting capacity, making it slower.

Coming now to the camera, it is fair to assert that for universal application in the hands of an amateur with a serious purpose, nothing possibly can be better than a five by seven inch folding "box," *with as long a bellows as the buyer can afford,* and fitted with all the devices for shifting the back and front; a ground-glass screen for focusing; a level and a plumb, for adjustments of position; and a rack-and-pinion movement for fine focusing of the image. The camera should be adapted for use either with glass plates or cut films, either separately or in "film packs" of a dozen units. The workmanship of all the cameras of good grade is most excellent; hence it is not essential to pay a fancy price for much lacquered brasswork. A plain, solid box with a stout bellows and the movements noted, may be had at a moderate price, and will last a lifetime if properly cared for.

We insist on as long a bellows as the buyer can afford. The novice does not appreciate the wisdom of this counsel; but after he has tried to do high-class book illustrating with a short-focus, wide-angle lens and a short bellows, he



Convergence of Beams of Light by Prisms.
The two beams A A' from a source S are converged at an approximate focus F by two prisms P P' set base to base. The focus is a confused patch of spectral color.

will assent. Twenty inches is about the right extension for a 5-by-7 camera with an 8-inch lens. Liberal bellows capacity will enable the operator to quadruple the

Day's Dying Glow.
A decorative theme based on the "reverse curve" traversing the foreground and ending with the dome-shaped foliage of the tree at the crest of the hill. Observe the abundance of subordinate detail in the foreground, and the simple beauty of the luminous distance against which, in tender silhouette, stands the principal mass of the picture.

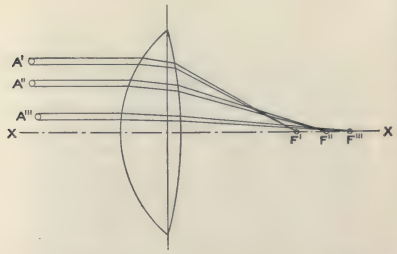
value of his outfit, at small additional outlay.

Suppose an engineer wishes to study at leisure the details of a novel truss or car truck. He will want as large an image of the device as his plate will hold; and if he possesses a long bellows, it will be possible for him to copy important details on a half-scale; whereas, with a fixed-focus box camera, his picture would be so small as to require a magnifier to resolve details.

The Anastigmat Lens

At the present time, all standard view and hand cameras are sold with common

doublet lenses of good qualities within limits, though ill-adapted to meet the exactions of the modern worker. Such



ACTION OF SINGLE LENS WITHOUT A STOP ON PARALLEL BEAMS OF LIGHT.

The parallel beams A' A'' A''' are focused at different points F' F'' F''' on the axis X.—The focal points are sharp, but not coincident nor achromatic.

stock lenses will answer for a time; but the ambition of every photographer, novice or adept, is to own an "anastigmat." Hence it will be well for the beginner, if his purse will permit, to buy a "Jena glass" objective at the outset. The question then arises in his mind—Which of several hundreds all "The Best," really *is* best? And this compels us to dwell in some detail on the differences between the new and the old types of lenses.

Avoiding the technicalities of the subject, we may say broadly, that the old optical glasses available prior to the discoveries of Schott of Jena, made it possible to form lenses capable of bringing to an approximate focus wave lengths representing two colors at or near the ends of the spectrum, and only two at the same time and in the same lens. The colors selected for this collection were, the one having the greatest ocular intensity, and the one of greatest chemical activity. By combining in a tube at precisely the correct positions two of these "simple achromatic" lenses, a doublet was produced, having sufficient elements of curvature, thickness, and separation to enable the opticians to correct some of the numerous errors of sphericity, but always at the expense of aperture and speed, or of angular field, or of marginal definition. With the old glasses, it was a physical impossibility to obtain a flat field without reducing the aperture; and even then the angular extent of the field was limited to a few degrees. It was impossible, mathematically and practically, to combine the old glasses in such a way as to eliminate "astigmatism"—that is, the fault in a lens whereby adjacent pencils of light coming from the same source fall in different focal planes. This is a very serious error, and it seemed to be incurable.

Schott and Abbé, however, discovered that certain silicates of barium afforded glasses in which refraction and dispersion varied inversely and abnormally,

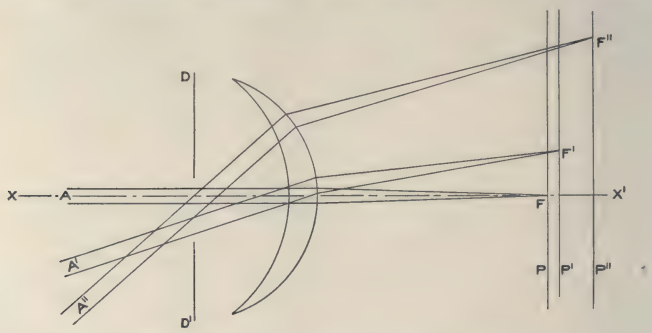


DIAGRAM ILLUSTRATING ACTION OF SINGLE LENS ON BEAMS OF LIGHT PASSING AT VARIOUS ANGLES.

The beams A A' A'' focus at F F' F'' in different planes P P' P''. Hence they cannot produce sharp images. The use of a small stop at D D', by cutting out beam of wide angle, improves the definition by making the planes P P' P'' approximately coincident for rays close to the axis X X'.

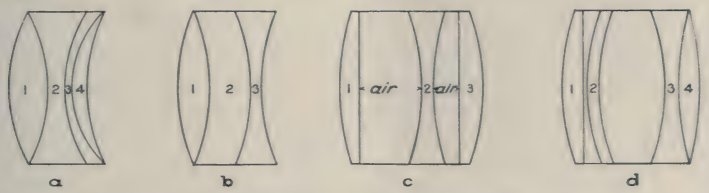
complying with the theoretical specifications furnished by Dr. Abbé and Prof. von Seidel. Then, and only then, it be-

came possible to construct lenses free from all the gross errors of the old types, and approximately devoid of all spherical and chromatic aberrations, both primary and secondary. The new glasses, however, do not render the old useless, since the theory of modern construction requires not only abnormal but also normal pairs of glasses; and the perfect anastigmat necessarily involves the combination of old and new glass components, to effect all the necessary corrections.

Prime among the advantages of the new construction are these: Absence of curvature and of astigmatism over a very wide area; almost complete correction of all varieties of spherical error; approximately perfect elimination of errors of color; and the attainment of all these advantages without diminution of aperture—indeed, so much to the contrary, that all these merits now exist in lenses having the enormous focal-aperture of F/3.6.

It is needless to say that the anastigmat lens is not a "fad." It is a scientific achievement of surpassing magnitude; and there is no sort of comparison between the new and the old that does not show the old to be vastly inferior. Still, where the purse rules in favor of the old type, and the matter is not open for debate, it is comforting to know that the common stock lenses of the present day are much better than the precision objectives of the time before Frauenhofer. In fact, the uncritical amateur may never become painfully conscious of the limitations of his cheap lens unless he happen to do work in comparison with that of an anastigmat. *Use the best tools you can afford.* That is the only rule.

The anastigmats are offered in endless variety and at all prices, depending on focal length and aperture—some convertible, some symmetrical, and some unsymmetrical. The ultra-rapid and the extreme wide-angle lenses are distinctly special objectives; and unless the worker requires them, he would better select a more generally useful objective, working at moderate speed, and capable of being used either as a doublet or as a long-focus single. This means a symmetrical anastigmat. For a 5-by-7-inch camera, an 8-inch lens should be chosen, assuming that the bellows is long enough to accommodate the 16-inch single, and give three or four inches for manœuvering at closer range. Such a lens, with an aperture ratio of F/6.3 to F/6.8 will be of universal utility.



A FEW TYPES OF ANASTIGMAT LENSES.

Constructed of Jena glasses, for the correction of all errors of color and sphericity. The lenses *a* and *b* are single lenses, capable of use alone or as symmetrical doublets; *c* and *d* are complete lenses of the dissymmetrical type.

The subject of lenses is much too complicated for brief discussion. If any reader desires to be fully informed on the technical and practical points involved, he can do no better than to read carefully Prof. Sylvanus Thompson's translation of Dr. Lummer's "Photographic Optics," in which the theory of aberrations and their corrections is fully developed.

Focus and Adjustment

Assuming that the worker is provided with such an outfit as we have described, and with the necessary plate-holders, tripod, focusing cloth, and dark-room paraphernalia, the next step is to understand how to use them advantageously. It is well to make sure, first, that the plate-holders, when in place, bring the surface of the sensitive plate into exact coincidence with the image as seen on the focusing glass. To insure this es-

sential, it is well to focus carefully with a magnifier some object of bold outlines, noting with care its features on the ground glass, and then exposing a plate without altering the position of the camera. If, on development, the image is found to correspond accurately with the object as focused on the screen, it is safe to approve the "register."

It is of almost equal importance that the lens shall be mounted on a front board accurately parallel with the plane of the plate. Any fault in this adjustment causes trouble when fine work is attempted. The finer the lens you use, the more vital it is to have the plate at a right angle with the axis of the objective. Incidentally, users of anastigmats ought to focus with the aid of magnifying glasses if they wish to obtain the best results. Carelessness in this particular leads to much disappointment.

Plates or Films?

The decision of the issue between plates and films resolves itself into a problem of convenience. The old "roll film" is no longer imperative, since cut sizes are readily obtainable, and packs of a dozen exposures may be had for adaptation to almost all cameras. The use of the film-pack enables the worker to focus his view on the ground glass just as with glass plates and at the same time gives him the considerable advantage of the light celluloid. For the tourist, films are the proper thing; but for the indoor worker, glass plates cannot be surpassed.

For all work likely to involve manipulation of the resulting negative, or special methods of printing, plates will be prescribed. For out-of-door work, where "non-halation" quality and extreme portability are desired, the film-pack should be chosen. Plates are cheaper; and during the apprentice stage of the beginner's career, he may well use them almost exclusively. Of great value, too, is the fact that plates are supplied with emulsions suited for a wide range of purposes—from the very slow emulsions to the most rapid color-sensitized varieties.

If copying is to be done, select a slow emulsion—either ordinary or "ortho," according to the problem in hand. For interior work, rapid non-halation plates are all but essential, to avoid the spreading of high lights and incidental troubles.

For landscape work requiring good rendering of "values," one must use isochromatic or orthochromatic plates, in either case with appropriate selective color screens.

The beginner can afford to learn most of his preliminary lessons with the cheap, ordinary plates, reserving for special occasions the higher-priced "orthos" and non-halation brands.

(To be continued)

Life Stories of Successful Men

James T. Harahan

By HENRY M. HYDE
Author of "The Buccaneers"

SHALL a young man who is ambitious to rise to a high position in the railroad world devote four of his early years to the business of acquiring a thorough technical education? Or shall he rather enter railroad work as early in life as possible, and become a student in the great school of experience?

It would seem, at first glance, as if James T. Harahan, Second Vice-President of the great Illinois Central system, furnished in his own career a sufficient answer to the double-barreled inquiry. For Mr. Harahan became a railroad man at the age of seventeen, and he has been at it ever since. He matriculated at the university of sharp eyes and hard knocks before he had had much education of any kind whatsoever. That he is to-day a man of good general information and of wide culture — to say nothing of his occupying one of the highest positions as a technical railroad man — is proof of the fact that some men, at least, are able to educate themselves while they pull in the harness.

Shall one say, then, that a youth is foolish to spend his time in technical study? Shall one advise him to jump right into the work and depend on what he can pick up? Mr. Harahan's career would seem to point in that direction. One may consider it settled, then.

But just as one has made up his mind on the subject, Mr. Harahan himself, by a strange paradox, knocks the argument into a cocked hat. For, when he had a son of his own to put into railroad work, the first thing he did was to send the boy to a technical school, where he remained until a degree as Civil Engineer was granted him. To-day that boy is the General Manager of the Illinois Central. So, in the one family, may be found arguments which are equally strong on both sides of the disputed question. Leave it to Mr. Harahan himself, and he will probably advise that the ambitious youth get a good technical education as foundation for what he must learn in actual practice.

In still another direction the career of James T. Harahan is somewhat puzzling. He furnishes the strongest possible evidence that the old proverb which declares that a "rolling stone gathers no moss" does not apply to the railroad business. Few men in any line of work have held so many different important positions in such a comparatively short space of time. Since the Civil War he has changed his position, on an average, once in two years. Sometimes these changes have been so rapid as to be confusingly kaleidoscopic. For instance, between October, 1888, and November, 1890, he served, respectively, as Assistant General Manager of the Lake Shore & Michigan Southern Railway, as General Manager of the Chesapeake & Ohio Railway, as General Manager of the Louisville, New Orleans & Texas Railway, and as Second Vice-President of the Illinois Central Railroad Company. Once on an average of every six months he made a change, but—and this is the important point—every change was a distinct step upwards.

Mr. Harahan had made many changes because, chiefly, of one exceedingly significant fact. He has always made it a point, while filling any position, to make himself thoroughly acquainted with the duties of the position immediately above it. This keynote to his character is well illustrated in an incident which occurred early in his life as a railroad man. He was serving as roadmaster on a certain division. In that capacity he had nothing

to do, officially, with the traffic on the road. His duties were to look after the roadbed and track. But, with the curiosity for useful information which has ever distinguished him, he thoroughly posted himself on traffic conditions. One day the General Manager of the road came over the division in his private car. He talked with each of the operating officials and found that practically all of them were well up on their own duties. But when he came to talk to the roadmaster, he discovered that Harahan knew not only all about the roadbed, track, and right of way, but that he was also familiar with all the details of traffic on the division. He went away, saying nothing; but not long afterward Mr. Harahan was surprised to receive a telegram asking him to take the superintendency of the road. That—speaking broadly and generally—has been the process ever since.

JAMES THEODORE HARAHAN.
Born in Massachusetts, 1843. Since 1890, Second Vice-President, Illinois Central Railroad Company.

When the Civil War broke out, Mr. Harahan was only seventeen years old, but he succeeded in getting into the army and saw much hard fighting around Richmond. Finally he was transferred to the artillery. Then, a little later, his superiors discovered that they wanted to use him in another capacity. While serving as a private, he had often been assigned to duty on railroad work. He took to it at once, and, when it became necessary to assign someone regularly to the army railroad service, young Harahan was naturally among those selected. For some time he worked as fireman, as engineer, as conductor, and as roadmaster on the Orange & Alexandria Railroad, under conditions which were calculated to try to the utmost the temper and the resources of a man. Mosby, the Confederate guerrilla chief, was operating along the line of the railroad; and it was exceedingly doubtful, every time a train went out, whether its crew would ever reach its destination. It was one of Mosby's amusements to remove rails, to put obstructions on the tracks, to do

all manner of things, with the purpose of impeding the passage of supplies for the Federal army. A railroad man who could successfully meet and cope with such conditions would hardly be likely to be daunted by anything he could possibly meet with in times of peace.

In that hardest of all possible schools, Mr. Harahan learned the railroad business—literally from the ground up. And there can be no possible question, that, for a complete and thorough training, no possible course of instruction could be better. To-day the Second Vice-President of the Illinois Central system knows how to fire an engine as well as how to direct the policies of the great road he serves. He knows—because he had the knowledge pounded into him—all about how to keep a roadbed in repair; he is quick to decide, in case of an accident, who is at fault, because he carries in his memory an exact list of the duties of every member of the operating force. It is small use to attempt to deceive a man like that. As a matter of fact, no one ever tries that game.

On the other hand, Mr. Harahan keeps—largely for the same reasons—in close personal touch with men of all grades along the whole Illinois Central system. He can pick up a section foreman anywhere along the system, give him a seat in his private car, and in half an hour's talk learn more about actual conditions than would be possible in a week to an official who had no intimate knowledge of the duties and difficulties of such a minor servant of the company.

The lesson of his career is, fortunately, a very plain and simple one. When he was a fireman he learned the trade of the engineer so thoroughly that the railroad company simply could not afford to keep a first-class engine-driver on the other side of the cab. When he became master of the throttle, he studied the roadbed and right of way so thoroughly that a railroad manager, with an eye to the highest efficiency, was forced to promote him again.

No sensible and progressive business concern of any kind can afford to let a first-class department manager, for instance, waste his time in acting as a shipping clerk. That's the lesson Harahan has to teach.

When a young man in a subordinate position shows ability and knowledge to fill one higher up, promotion is bound to come his way. And let no one deceive himself with the delusion that he will not get a chance to show such ability and knowledge, if they are among his possessions! Good men are too scarce for that.

Take Heart

THOUGH rain may fall, for long, long day,
And all the world seem drear and bleak,
Take heart, bear up, and strive alway,
For light, aye soon, must top the peak.

Pen and Ink Rendering

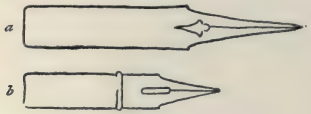
A Few Suggestions for the Beginner in this Fascinating Art

By DAVID A. GREGG

Instructor in Pen and Ink Rendering, Massachusetts Institute of Technology

TO render in pen and ink a large and important drawing, is no small accomplishment. Usually years of experience are necessary before one can successfully undertake such drawings. Now and then a student is to be found having talent to the extent that the attainment of this skill seems a very easy matter, but in general this talent is comparatively rare. Ninety-five out of every hundred have a long task ahead before success is possible. This difficulty of attainment, however, makes the accomplishment all the more valuable.

There are three ways in which sketches are commonly rendered—namely, with pen, pencil, or brush. Pen rendering admits of stronger contrasts, hence more sparkle or brilliancy; pencil



STEEL PENS.
a—Esterbrook Bank Pen, No. 14. *b*—Gillott, No. 404.

rendering is quicker, and permits of softer tones and more sketchy effects; brush rendering is by washes either in color or in India ink, and produces an entirely different effect from pen or pencil work.

In pen rendering, the tendency of beginners is to use too fine a pen. It must be remembered that many pen drawings are reproduced much smaller than the originals, and consequently the lines appear much finer than in the drawing itself. There are two pens that can be recommended, shown herewith. Years of experience prove them to be perfectly satisfactory. Occasionally a finer pen is needed, such as Gillott No. 303. The Esterbrook No. 14, a large pen, is necessary in making the blacker portions of a drawing. The Gillott No. 404 is used for general work in the same drawing.

Ink is not of so much importance as pens. The various prepared India inks put up in bottles are all that can be desired. They are more convenient than ink that must be rubbed up, and they have the advantage of always being properly black. Some ordinary writing inks serve the purpose very well if reproduction is not an object; but if reproduction is desired, India ink, being black, is preferred.

In the matter of paper, the very best surface is a hard Bristol board. The softer kinds of Bristol board should be avoided, as they will not stand erasure. Most of the drawing papers do very well. Whatman's hot-pressed paper is very satisfactory. An excellent drawing surface is obtained by mounting a smooth

FIG. 1. GOOD QUALITY OF LINE.

paper on cardboard, thus obtaining a level surface that will not spring up with each pressure of the pen. This is equivalent to a Bristol board. However, the size of Bristol board is limited and frequently drawings must be much larger, in which case the mounted paper is a necessity.

Too much stress cannot be laid on the importance of a good line, however insignificant it may seem. Care in each individual line is absolutely necessary for

FIG. 2. EXCELLENT METHOD.

good work. A line that is stiff and hard, feeble, scratchy, or broken, will not do. Such work will ruin a drawing that in other respects may be excellent. The accompanying illustration (Fig. 1) is an example of excellent quality of line. Each line, even to the very smallest, has grace, beauty, and character. By a very few, the ability to make such lines is speedily acquired —but by a few only—others attain it only after patient, careful practice.

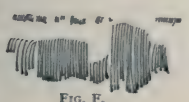


FIG. F.

Every line of a drawing—the outline of the building and each line of the rendering, even to the very shortest—must

FIG. 3. VERTICAL LINE METHOD.

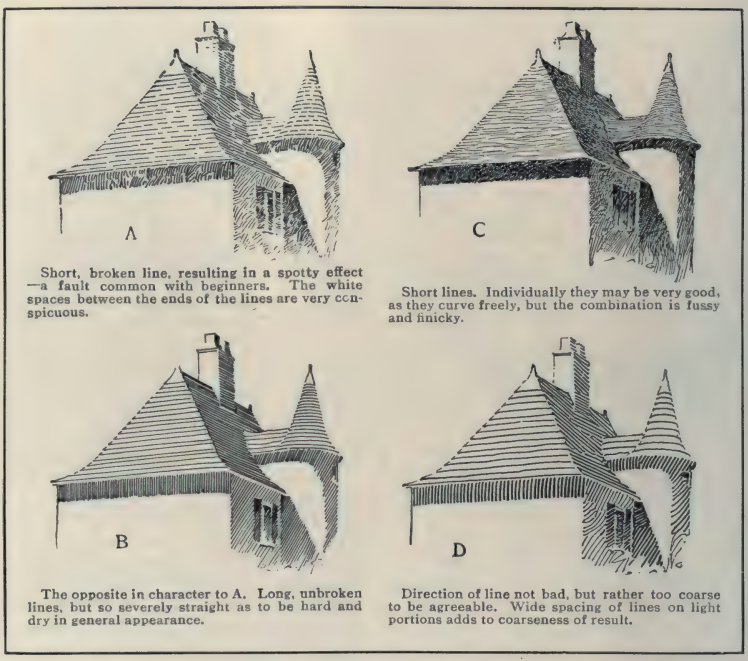
be done feelingly, gracefully, positively. Usually a slight curve is advisable, and, if long lines are used, a quaver or tremble adds much to the result. Each line of a shadow should have a slight pressure of the pen at the lower end (Fig. F). This produces a dark edge in the group of lines that make the shadow, giving definiteness to the shadow and contrast to the white light below it.

The combination of individual lines produces what we may term a *method*. The individual line may be good, but

FIG. 4. FREE LINE METHOD.

the combining may be unfortunate. In making a wash drawing, no thought is necessary concerning the direction of the wash; but in using lines, the query at once arises as to what direction they shall take. A method is something one must grow into from a small, simple beginning. The accompanying illustration (Fig. 2) is an example of rare skill in method. There is an utter absence of anything rigid or mechanical in the whole. Observe how softly the edges of the drawing merge into the white of the paper. The vigor of the drawing is gathered in the doorway itself.

The simplest method is obtained by the use of the vertical line. Some drawings can be made entirely by this means. See Fig. 3, every line of which is vertical. This illustrates the value of a good individual line. It will be observed that, although vertical, these lines are not severely straight and stiff; they tremble a little, or have a slight suggestion of a curve. In the shadow at the bottom of the drawing, each line is emphasized at the top by a light pressure, and made thin at the lower end in order to soften off the edges of the drawing as a whole.


A
Short, broken line, resulting in a spotty effect—a fault common with beginners. The white spaces between the ends of the lines are very conspicuous.
C
Short lines. Individually they may be very good, as they curve freely, but the combination is fussy and finicky.
B
The opposite in character to A. Long, unbroken lines, but so severely straight as to be hard and dry in general appearance.
D
Direction of line not bad, but rather too coarse to be agreeable. Wide spacing of lines on light portions adds to coarseness of result.

VARIOUS METHODS OF RENDERING.

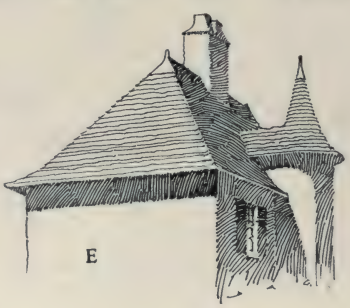


Fig. 4 shows another method. The vertical line is discarded and the freest possible line is used. No one direction is

followed, but the lines go in any or all directions. Which is the better method? The answer doubtless must be that the free method is the less conspicuous. It is better adapted for general use—the more natural—in the showing of various surfaces and textures.

The five illustrations on page 758 show various examples of method. In Fig. A the short, broken lines result in a spotty

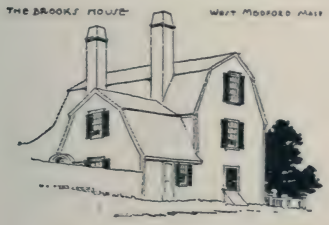


Fig. 5. Black and White.

effect caused by the white spaces between the ends of the lines. This is a very common fault with beginners. Fig. B goes to the opposite extreme. Long, severely straight lines produce a stiff, mechanical effect which is very unpleasant. In Fig. C there is greater freedom, and the feeling in the lines is very good. The lines are too close together, however, producing a fussy, scratchy, labored effect. Fig. D is an example of lines that are too heavy and too widely spaced. The direction of the lines is good, especially on the side roof, but the effect is too coarse to be artistic.

The four figures mentioned illustrate faulty methods that are very common among draftsmen. In Fig. E an effort is made to avoid all the faults shown in the others—the harsh, stiff, coarse line, the spotted effect, and the scratchy, labored combination. The lines are free and natural, and the effect is soft and artistic.

If several lines are drawn parallel and quite close together, but not touching, a gray color is the result. This is termed

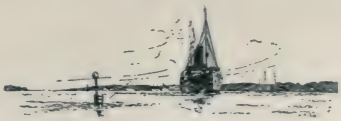
Fig. 6. Gray and White.

a *half-tone* value. Lines drawn so close together that the ink of one runs into that of the other, with little or no white space between, give a black value. The white of the paper untouched by the pen gives a white value. Fig. 5 shows only two values—black and white; Fig. 6 also has two—gray and white; Fig. 7 has the three—black, gray, and white. The first

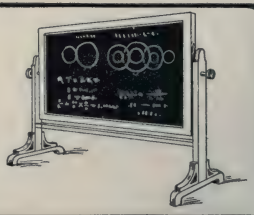
Fig. 7. Black, Gray, and White.

is harsh; the second is pale; the third seems the most satisfactory.

This is a safe rule to follow—Get into every pen drawing, black, gray, and white. Usually, in early attempts, there is a tendency to omit the black. Look for the place in the drawing where you can locate this black; you are not likely to get too much of it. Let the half-tone or gray be rather light, midway in strength between white and black. A heavy half-tone is a dangerous value. The black may often grade off into the gray, or there may be distinct fields or areas of each value.



CHALK TALKS



by CARL S. DOW.

Number Twelve—The Dynamo

THERE are two common methods of generating electromotive force —by chemical action in a battery, and by moving a conductor in an electric field. The machine which produces electromotive force by the last-named method is called a Dynamo or Electric Generator. Before considering the generator, let us consider the subject of magnetism and the magnetic field.

The Magnetic Field

A permanent magnet is a piece of steel which has the property of attracting iron and steel. Experiment shows that the space immediately surrounding a magnet, called its "field," is subject to the influence of the magnet. This influence is exerted in definite directions or lines, which are called "lines of magnetic force," or, simply, "lines of force." The first figure on the blackboard represents the lines of force of a bar magnet; and the second shows the field of a horseshoe magnet.

The strength of the field is proportional to the number of lines per square inch of cross-section, or "density," as it is called.

The Conductor

When a current flows in a conductor (a copper wire), the conductor is surrounded by circular lines of force, as shown in the third figure. When the steam pipes of a radiator are giving off heat, the greatest heat is in the air immediately surrounding the pipe. Similarly, in the case of the conductor, the greatest density of the lines of force is near the conductor; at a slight distance, the field is comparatively weak.

The Dynamo

It has already been said that when a current flows in a conductor, a magnetic field is created around the conductor. Conversely, if a magnetic field is created around a conductor, electromotive force will be induced in it. This, then, is the fundamental principle:—*To obtain electromotive force, there must be relative movement between a conductor and a magnetic field.* Either the field or the conductor may be the part in motion.

If the dynamo be constructed according to the above—that is, consisting of a simple bar magnet, and a conductor moving in the field—an electromotive force will be generated and current will flow, if the circuit be closed. Such an arrangement, however, would produce but little electromotive force; and, moreover, the machine would not be efficient. In order to increase the power developed, certain changes are introduced:

(1) The magnet is greatly strengthened by winding wire which carries a current, about a soft iron core; this, of course, strengthens the field also.

(2) The iron core is extended and shaped so that the poles will be close together. This is shown by the fourth

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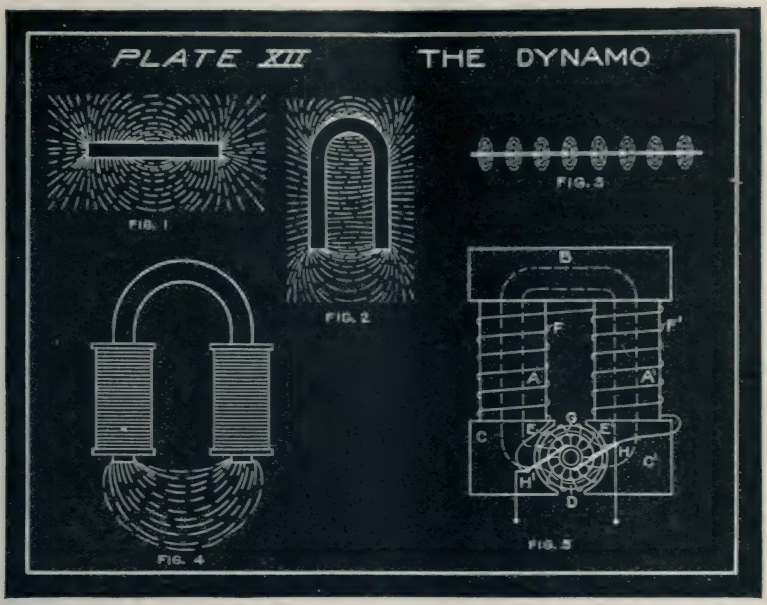


figure on the blackboard. The curved shape, and the slight distance between the poles, result in a convenient form and a strong field.

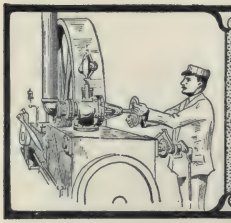
(3) The conductor, instead of being a single wire, is made up of a soft iron core and coils of wire, so that the number of convolutions will be increased.

Parts of the Dynamo

The fifth figure on the blackboard shows diagrammatically the arrangement of the parts of the dynamo. The field cores are shown at A and A'; the field windings, at F and F'; the yoke, at B; the pole pieces, at C and C'; the armature, at D; and the armature coils, at G. The spaces between the pole pieces C and C' and the surface of the armature, are called the "air gaps," shown at E and E'.

These are always made as small as mechanical considerations will permit, so that the distance in air through which the lines of force must pass, may be as small as possible. The brushes H and H' are for the purpose of collecting the current.

The dotted lines show the path of the magnetic lines. These lines pass through the yoke, the field cores, and the pole pieces, then pass across the air gaps and through the armature core.



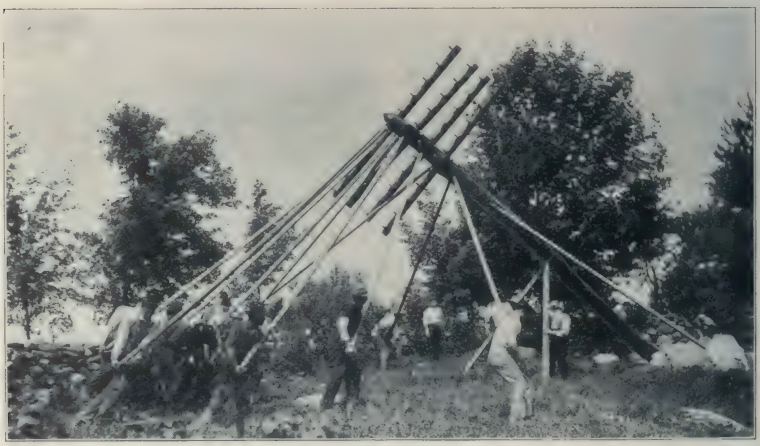
ENGINEERING PROGRESS

A Telephone Pole-Derrick

SOME remarkably quick work has been going on this past summer in the construction of a new long-distance telephone service between New York and Boston, the crew completing a daily average of more than 3,000 feet of line. Probably more telephonic messages are transmitted annually between these two centers than between any other two cities of the world; and the American Telephone & Telegraph Company, which planned the new avenue of communication has determined to create the best telephone and telegraph line in existence. An efficient aid in the undertaking has been a newly invented pole-derrick, which was devised by one of the foremen of construction of the Bell system. Ordinarily the great chestnut or cedar poles, weighing a couple of tons or more, are erected by a score of men struggling with unwieldy pike-poles; but this simple apparatus enables four men without difficulty to do the work of twenty.

The new contrivance consists of a heavy wagon, with two 28-foot spars which stand like an inverted V, one leg over each pair of wheels. When the derrick has been dragged to the vicinity of a pole hole, it is guyed to nearby trees or rocks—or, by an arrangement of crowbars, to the ground—in order that the heavy pole may be raised without overturning it.

Once the apparatus stands ready, the men screw on the pole cross-arms and



TELEPHONE LINE CONSTRUCTION.—OLD METHOD OF POLE RAISING.
A score of men push the big timber upward.

spike their supports. A strong logging chain is passed around the pole, well above the center of gravity; and the horses are hitched to the draw-rope. At a signal from the foreman, the horses start on a steady, even pull, whereupon the ropes tighten, the blocks creak, and straightway the big stick swings clear. Two of the men guide its butt; and, as soon as this is squarely over the hole, the horses back slowly, and the stick drops into place. Thereupon the foreman climbs the shaft, removes the chain, and gives orders for the horses to be hitched up again and the derrick moved on to the next pole. Meantime the pole is straightened up by the "fillers," and the earth is thrown in about it. Such a derrick, requiring but four men, two horses, and a boy driver, saves from fifteen to twenty dollars a day in wages.

This particular construction crew has been aided also by a "reel wagon" which allows them to string ten wires simultaneously. The essential feature of this is a specially constructed wagon with five wire-reels placed horizontally on either side. It is said to be a great improvement over the old method of stringing wires.

TELEPHONE LINE CONSTRUCTION.—POLE-DERRICK IN OPERATION.
By means of this device, four men are enabled to erect a two-ton pole.

"Key Route" Electrical Line

THE noted "Key Route" Electrical Railway in California is in many respects unique. This double-tracked line is about twelve miles long, extending from San Francisco to the outlying suburban cities of Oakland and Berkeley. It has only recently gone into active operation.

TERMINAL OF "KEY ROUTE" ELECTRIC RAILWAY.
The station is at the end of a mole extending 3¼ miles into the waters of San Francisco Bay.

Boats run regularly from the dock at San Francisco over to the end of a very long mole, where is located the large depot. This mole is one of the longest in the world, the distance from the mainland to the depot being 17,160 feet, or 3¼ miles. The water of San Francisco Bay along the line of the mole averages 20 to 30 feet in depth, according to the tides; and the construction of the long track-way was a very expensive undertaking.

None of the ordinary poles and trolley wheels are used on the railway. What is known as the "Brown roller trolley," the invention of Mr. J. Q. Brown, General Engineer of the line, has been adopted. A roller two feet long is attached to the top of a diamond-shaped iron device. By means of strong steel springs, the roller is pushed up and kept in constant contact with the overhead current wire. The device is so constructed as to allow a vertical play of six feet in order to conform to variations of grade.

With the roller trolley there is no "jumping the wires," as with the ordinary narrow-grooved wheel. This cannot occur unless the car itself leaves the track. The roller is of great advantage also in running around curves; for, even at high speed, it cannot possibly "skip" from the wire. It simplifies greatly the overhead construction, doing away with all trolley frogs and switches except at right-angle crossings, where a simple special design is employed.

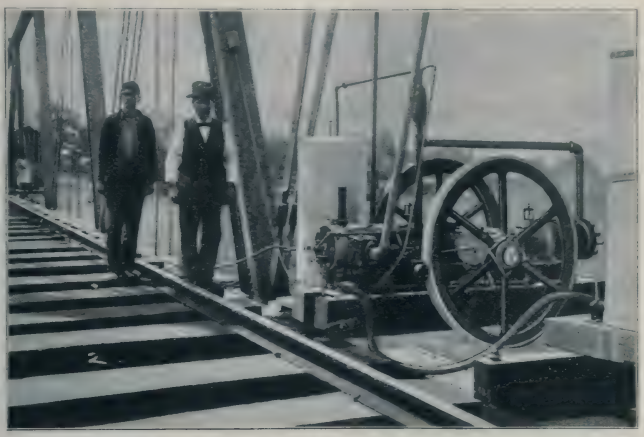
The wear on the trolley wire, also, is smaller than with the wheel. The roller soon wears smooth and bright, and does not become corrugated and pitted. The device is practically noiseless, for the roller is packed with non-resonant matter that almost entirely destroys the vibration. There is but very little jar even when moving at a high rate of speed, while the train runs very smoothly and steadily. The roller exerts an upward pressure of only 24 pounds against the trolley wire. To operate a train of eight cars moving at a speed of 50 miles per hour, requires from 2,500 to 3,000 amperes to be collected from the overhead conductor.

A Sledge Locomotive

IN the Maine lumber districts a very curious motor is utilized to haul logs through the woods in winter time. It is what might be called a "sledge locomotive," for, in place of the ordinary wheels, the front part is mounted on runners as well as the rear. Under the heaviest part of the motor, however, is placed a wheel

LOG-HAULING TRACTION ENGINE.

with broad tires fitted with teeth, which is connected with the main shaft of the engine. This wheel furnishes the traction which forces the motor along; and such is the power developed, that the machine will haul two or three car-loads of logs along a fairly level road through the woods, at the rate of from four to six miles an hour. It is brought into use after the snow has fallen sufficiently to form a fairly smooth surface for the runners, and it will ascend quite a steep grade.



SEMI-PORTABLE COMPRESSED-AIR PLANT USED IN BRIDGE REPAIRING.

Compressed Air in Bridge Repairing

A UNIQUE feat of bridge repairing, recently performed on the Illinois Central Railroad, shows the high state of efficiency that compressed-air machinery has attained, and the important new fields that it is invading. By the aid of a portable gasoline air-compressor, field riveting was done on a railroad bridge without in any way hindering traffic over the structure. The compressor was set outside the rail a sufficient distance to permit the passing of trains. An entirely new floor system was riveted in position in this particular bridge, without interfering with the passage of trains. The compressor occupied a central position on the bridge, and air lines were led in either direction from the receiver tank.

Since this performance, similar arrangements have been put in operation on the Illinois Central, on both new and repair work. The machines are generally placed in care of the superintendent; and after they are started, little or no attention is necessary, except the filling of the oil-cups. The arrangement of the compressor is automatic and is under the control of the engine's governor, thus making it economical, both in the use of fuel and in effecting a great saving in attendance.

English Railway Adopts Electricity

THE Northeastern Railway of England is the first road in Europe to grapple in a big way with the problem

THE GREAT WESTERN AUTOMOBILE.

created by the increased cost of operation of steam railroads and the increasing competition of electric roads. It has equipped 40 miles of the busiest portion of its line with electricity, using the third rail,

English Electric Railroad Train.

and has thus become a pioneer in the substitution of electrical for steam motive power.

It would be difficult to find a road where the conditions were more unfavorable for the success of electrical operation than on the Northeastern, but the promoters have already proclaimed the experiment an absolute success. Traffic over the forty miles is exceedingly heavy; there are four tracks nearly all the distance; and crossings and other obstacles are numerous. The electric trains that have been installed consist of two motor coaches, with one trailer coach between them. They are operated by a continuous current obtained from a single collector placed in the six-foot way, with a return circuit through the running rails. The collector rail weighs eighty pounds to the yard, and is placed 3 feet 11½ inches from the center of the track, and, where necessary, is protected by two creosoted boards bolted against distance pieces on each side of the rail. Under the protected rights of way of English roads, a third rail needs little protection, which is extremely different from the condition presented by American roads.

The electric rolling stock consists of motor and trailer coaches of the open-corridor type, lighted and heated by electricity. Each motor car is equipped with two motors, each of 150 horse-power. The motors used in the freight service are capable of hauling a train of 150 tons up a grade of 1 in 27 at a speed of between nine and ten miles per hour. For the present the accommodation trains between Newcastle and Tynemouth will run at an average speed of about 22 miles an hour, including stops; and the express trains, at about 30 miles an hour.

Ingenious New Panel-Board

SYSTEMATIC arrangement of circuits, avoiding all confusion such as often results in the wiring of large office buildings, is the result of a new type of panel-board installed in the great Railway Exchange Building in Chicago, Illinois. The panel-board is compact, and at the same time

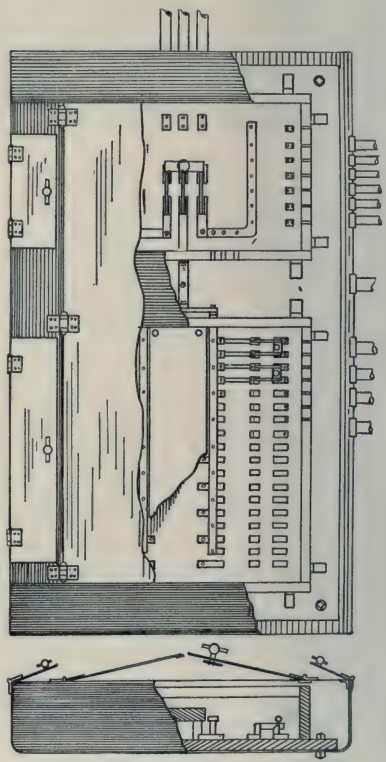


Fig. 1. Panel-Board for Office Buildings. —General Arrangement.

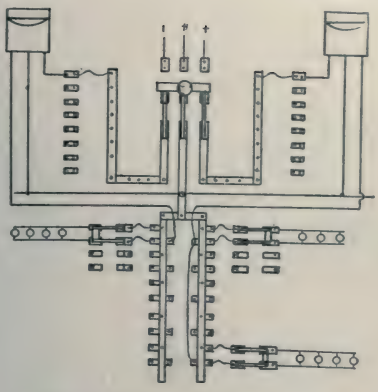


FIG. 2. PANEL-BOARD FOR OFFICE BUILDINGS. —CONNECTIONS TO METER.

gives great flexibility in connecting the various circuits in the building to the metering system.

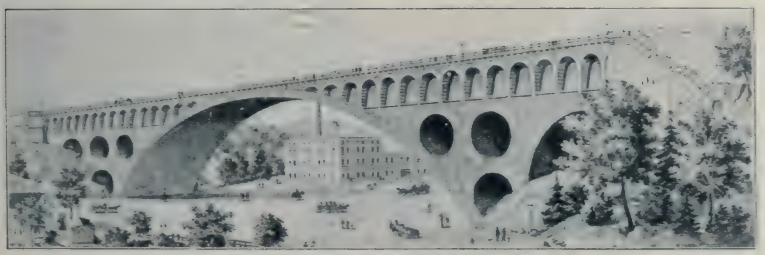
The general arrangement and connections of the device are shown in the accompanying illustrations. The board is mounted on a shallow steel box and is divided into two sections, vertically (Fig. 1). At the top the feeders from the three-wire service enter, and are led through the fuses to the main switch. The neutral passes from the switch down to two bus bars in the lower portion of the board. These bus bars are common to one side of each of the office circuits. The other side of each individual office circuit ends in a terminal on the board, and from this terminal a wire is carried up to the customer's meter, the current passing from the meter back to the other side of the main circuit, as shown in Fig. 2. In the latter figure, one of the meters is shown as registering on the two right-hand circuits at the top and bottom of the panel. When the lower one of these offices is to be vacated and the other retained, the meter can readily be changed to the one circuit by merely removing the jumper wire connecting the two, thus disturbing no other wiring.

The wiring of all the meters served by each panel-board is brought in at the sides near the top (Fig. 1), and the lamp circuits lead out opposite their respective switches at the lower portion of the board. The wiring on both sides is identical, although Fig. 1 shows it as entering one side.

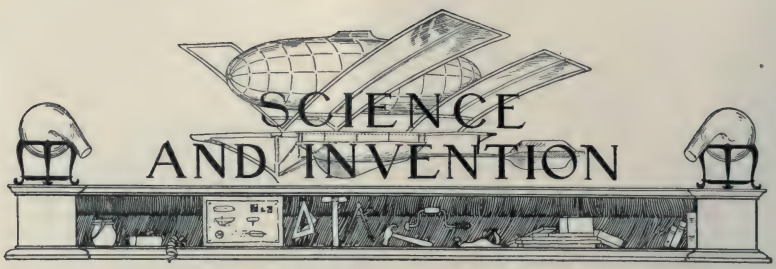
Unscrewing two marble slabs at the rear, covering the fuses and wiring, gives access to the panel itself. Two small doors at the top and bottom of the case near the edge (Fig. 1) can be opened, to show at a glance which leads are connected to the respective fuses.

World's Largest Stone Arch

SO rapid is the progress made these days in almost every line, that already the record of the noted Luxembourg bridge, completed in 1903 (See THE TECHNICAL WORLD, November, 1904, p. 311), has been beaten by a single-span structure erected in 1903-04, at Plauen, Germany, which now ranks as the longest stone arch in the world. The Plauen bridge is about 59 feet high and 55 feet wide. The length of the span is 90 meters (over 295 feet). The structure cost 500,000 marks, or about $119,000.



LONGEST STONE ARCH IN THE WORLD.
Erected at Plauen, Germany.—Length of span, nearly 296 feet.



Electric Danger Signal

A NEW electric signal has been installed along the line of the Aurora, Elgin & Chicago Electric Railway, for the prevention of grade-crossing accidents. It is an electric light which flashes at right angles with the railway tracks at street intersections, so that passengers on foot or in vehicles approaching a crossing are warned of the coming of a car while yet a long distance away. At the same time, an electric bell starts ringing.

The light consists of an 80-candle-power arc, and is so arranged as to shine only up and down the intersecting streets, and not upon the track. It is set in operation on the approach of a car, by an electric contact similar to that employed in the block signal system.

NEW ELECTRIC DANGER SIGNAL.
Bell and lights as they appear at a grade crossing.

NEW ELECTRIC DANGER SIGNAL.
Controlling device as it appears at side of rail.

The new device is the joint invention of Samuel E. Johnson, station agent at Lombard, and Joseph E. Sauers, of Wheaton. The signal during the daytime is the electric bell which formerly did duty alone. Mr. Johnson, in a description of the device furnished THE TECHNICAL WORLD, says:

"The bell is started by the first wheel of a train. The contacts are set mechanically and are held electrically. The controlling device or starter is connected in series with the bell and five 120-volt incandescent lamps, the lamps being used to cut down the electromotive force

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SCIENCE AND INVENTION—(Continued)

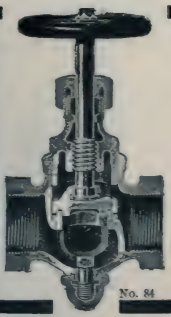
supplied to the bell, as the signal is operated by the current from the feeders for operating the cars. The lamps also light up the crossing at night when a train approaches. The controlling device, bell, etc., must be insulated on account of the high voltage (600). The system is arranged to protect the crossing for trains running on either track. The distance between the starting device and the bell may be anywhere between 500 feet and 5,000 feet."

Automatic Photography

THE passenger train shown in the accompanying engraving was running at an estimated rate of 50 miles an hour when the photograph was taken. Yet, the image stands out as clearly as if the

SNAPSHOT OF TRAIN RUNNING 50 MILES AN HOUR. Camera was opened and closed by electric device operated by the train itself.

train were motionless. This is an excellent illustration of what might be called "automatic picture-taking," for the train literally took a snapshot of itself. The camera was set up at the side of the track, fixed at the proper focus, and the shutter of the lens arranged for an instantaneous exposure. In this case the shutter was estimated to have a velocity giving an exposure of only one thousandth of a second. The movement of the shutter was controlled by compressed air, and the valve connected with an electric battery from which a wire was extended to the railroad track. The contrivance was arranged by the photographer in such a way that the instant the front wheel of the locomotive came in contact with the rail at the point where the wire was attached, an electric current would release the shutter valve and make the exposure.



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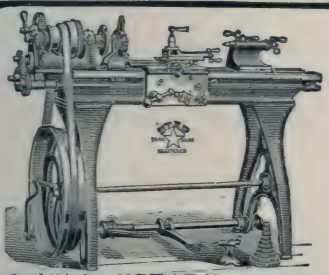

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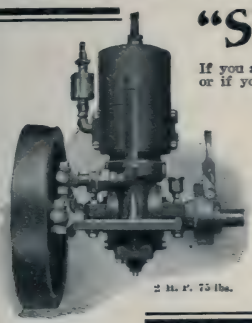

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SCIENCE AND INVENTION—(Continued)

Automatic Fire-Alarm

A UNIQUE device at a newly opened hotel in New York, attests the importance which mine host attaches nowadays to automatic appliances for fire protection.

The contrivance consists primarily of a thermostat with an ammonia diaphragm attached. This diaphragm, which is about the size of a five-cent piece, is airtight, filled with ammonia, and fastened inside the thermostat. In the ceiling of each of the 500 or more guest chambers of the hotel, is set one of these fire-alarms, connected by electric wire with an annunciator in the main office of the hotel. On the disc of the annunciator appear the various room numbers. If a fire breaks out in any room, the ammonia boils directly the heat reaches 130 degrees, expanding the diaphragm, and establishing an electrical contact with the wire leading to the annunciator, thus automatically giving an instant alarm. If, for example, a fire breaks out in room number 290, a glowing red light appears against the corresponding number at the central station.

Nor does the system end here. The annunciator is connected with an alarm gong located in the engine room, where the hotel's fire crew of ten well-drilled men are constantly on duty. Immediately the alarm is given, these men board a special elevator maintained to be used only in case of fire, and are conveyed straightway to the scene of trouble. So perfect is this system of fire protection that it seems hardly possible for a conflagration to gain headway where it is installed.

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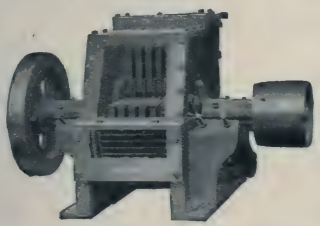

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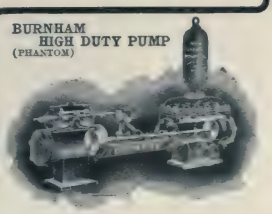

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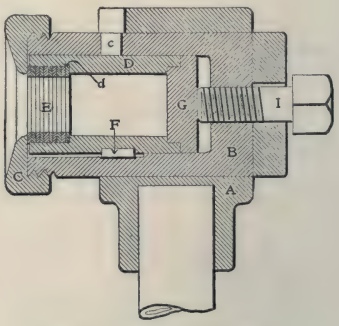
placed and clamped rather freely by a coarsely threaded hand nut, and finally pinched tightly by a set screw, the tapping being done in a lathe or tapping machine as desired.

A is a cast-iron holder with a pipe handle; and fitted into it is the steel sleeve *B*, which has at one end two turns of a very coarse thread whereon is



DEVICE FOR TAPPING THIN NUTS.

screwed the hand nut *C*. The pin *c* prevents the sleeve *B* from turning in the holder *A*. Inside *B* is the inner sleeve *D*, with the recess *d* to receive the nut blanks *E*. A key *F* prevents *D* from turning. At its rear end is fitted a disc *G*, upon which bears the set screw *I*, whereby the nuts are clamped in.

The method of operation is to place the nuts in the recess *d*, and screw up the nut *C* by hand, which is very quickly done. Then a small part of a turn of the set screw *I* with a wrench, clamps all firmly for the tapping, upon the completion of which the operations are reversed.

The Verant

IN stereoscopes, as is well known, plastic vision is ensured through the combination of two separate views of the same object, corresponding to the images formed by the original in each eye respectively. The superposition of these two images produces an impression much

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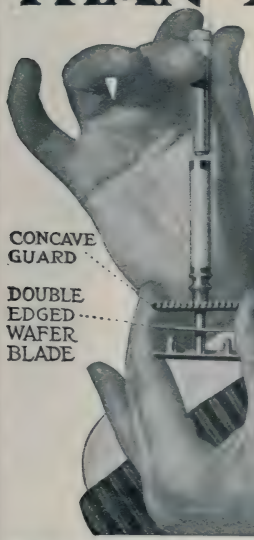

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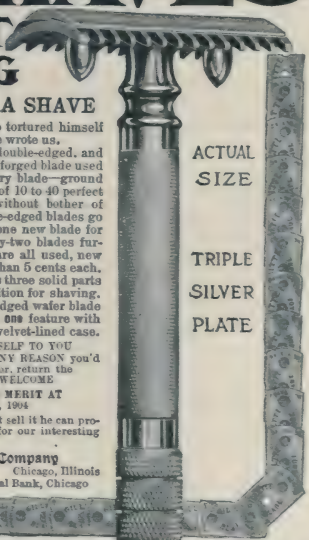

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SCIENCE AND INVENTION—(Continued)

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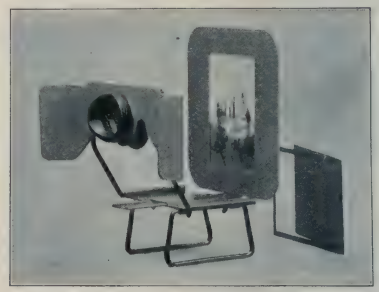

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A Device for Securing Plastic Vision with a Single Picture.

which the objects present themselves to his eye if the latter be placed at the point of the photographic objective and directed successively to the different points of the object. This is why an ordinary picture fails to convey the impression of plasticity which we obtain through the direct inspection of the object the photographs are taken from. Such plastic effects could be obtained only by means of a magnified copy of the photograph, which, apart from the additional trouble and cost, would be disturbing in the case of the image of a distant object (landscape or building) having to be viewed from a relatively small distance.

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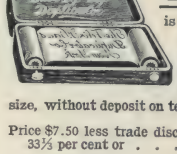

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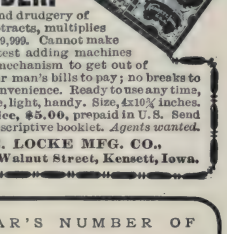

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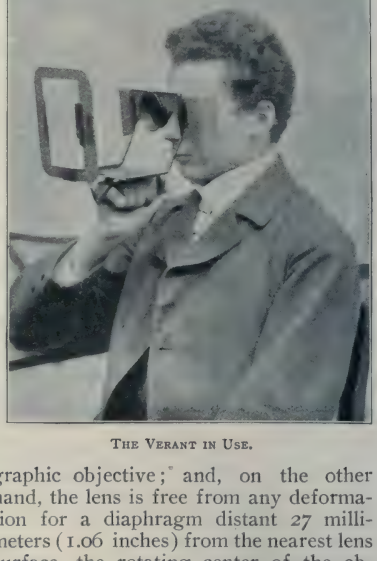
SCIENCE AND INVENTION—(Concluded)

This is ensured by using an achromatic lens satisfying two additional conditions:—the focal distance, on the one hand, is fairly identical with that of the photographic objective; and, on the other hand, the lens is free from any deformation for a diaphragm distant 27 millimeters (1.06 inches) from the nearest lens surface, the rotating center of the observing eye having to be placed at that point.



THE VERANT IN USE.

These different conditions will result in a normal eye view instead of the small photograph, a distant image of the latter being free from any deformation (if the eye be placed at the point of no deformation), and fulfilling the same conditions as to apparent size, shadows, and relative distinctness as in the case of the objects being inspected from the objective of the photographic camera. The impression thus produced by the small photograph will be much more true to nature; and the main consequence will be an unconscious production of a true image agreeing with the different marks observed. The photograph as observed through the apparatus will therefore produce quite as plastic effects as in the case of being regarded with both eyes through a stereoscope.—DR. A. GRADENWITZ.

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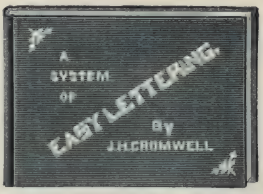

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Question 2: How can I make an electro-gilding bath which gives a red color like 14- or 18-carat gold?—*J. V. C.*

Answer 1: Dry cells are sold at such a low price that it does not pay an individual to spend his time in the manufacture of a cell. A dry battery may be made in the following manner:

A jar of the desired shape is made of zinc; heavy sheet zinc should be used and bent into the required form, then soldered in such a manner that it forms a jar. It will be found difficult to solder zinc. All parts where it is desired the solder should stick should be carefully cleaned by scraping, and clean chloride of zinc used as a flux. The zinc should have a brass binding-post soldered to it. The other electrode is usually carbon, and should have a similar binding-post fastened to it.

The contents of such cells vary. In Gassner's cell, the following mixture is used:

Oxide of zinc, 1 part by weight; sal-ammoniac, 1 part; plaster of paris, 3 parts; chloride of zinc, 1 part; and water, 2 parts.

The cell is sealed by means of covering with pitch, or some similar material which will not allow salts to creep. There are many other formulæ for the contents of the cell, which are used with success.

Answer 2: The following solution, recommended for red plating, should be used hot (at the boiling point) with a platinum wire for the anode and with high current density:

Phosphate of soda (crystallized), 60 parts; bisulphite of soda, 10 parts; cyanide of potassium (C. P.), 1 or 2 parts; neutral chloride of gold, 2 parts; distilled or rain water, 1,000 parts.

First dissolve the phosphate of soda in 800 parts of hot water. When thoroughly dissolved, filter the solution if not clear, and allow to cool. Dissolve the gold chloride in 100 parts water, and the bi-

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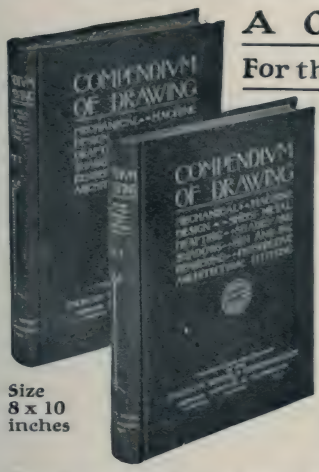

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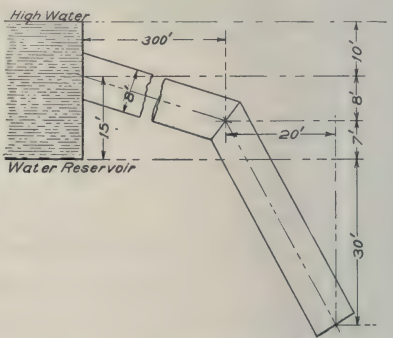
CONSULTING DEPARTMENT—(Continued)

sulphite of soda and cyanide in the remaining 100 parts. Pour gold solution slowly, with constant stirring, into the phosphate solution, which acquires a greenish or yellow tint. Now add solution of bisulphite and cyanide promptly, and the solution becomes colorless. If this does not give deep enough red, use a gold cyanide solution with the addition of a little copper cyanide.

Turbine Tube

Question: Kindly give me the necessary information how to design the turbine tube shown in the accompanying sketch. The tube is 8 feet in diameter and made of steel plate. What is the pressure against the sides of the tube at the different heights; and how thick shall the plates be to withstand the pressure, the allowable stress being 12,000 pounds per square inch?—*C. W. B.*



Answer: The pressure at any cross-section of the pipe can be determined by multiplying the head in feet at that section by the factor .433. The greatest pressure on the first 300 feet length of pipe will be that due to the head of 18 feet. This corresponds to a pressure of 7.8 pounds per square inch. The greatest pressure on the last section will be that due to the total head of 55 feet, and is equivalent to 23.8 pounds. By use of the following formula, the necessary thickness of the tube can be determined:

$$t = \frac{D \times P}{2 \times S \times E},$$

in which t is the thickness in inches; D, the diameter in inches (96); P, the press-

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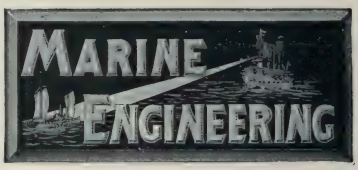

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ure in pounds per square inch due to the head; S, the allowable working stress (12,000 pounds); E, the efficiency of the joint (.7, assumed). Substituting the value of P (7.8) for the first section, we have

$$t = \frac{96 \times 7.8}{2 \times 12{,}000 \times .7} = .0445 \text{ inch.}$$

In a similar manner we find the value of t for the lower section to be .136 inch.

The above calculations allow for the static pressure alone.

When the water is passing through the tube, there will be certain dynamic forces, caused by change in direction at the bend. This will necessitate bracing the pipe at the bend mentioned, and, of course, it should be properly supported throughout its length.

Cadmium Test

Question: Kindly inform me of the proper test of storage batteries by means of the cadmium stick, and how to conduct such test.—*R. G. H.*

Answer: The voltage of a battery does not always indicate the state of charge. One method of finding the amount of charge in a storage battery is called the "Cadmium Test." The apparatus for making this test may consist of a small piece of cadmium, 5/8 inch by 5/8 inch by 1-32 inch, mounted so that a glass tube contains the conducting wire, wax being used to protect the soldered joint of copper and cadmium. With normal conditions of cell when fully charged and on open circuit, the difference of potential between the cadmium piece and the positive plate is approximately 2.5 volts, which is sufficient. The cadmium test is usually made at the center of the cell, giving uniform current distribution. The test will give readings, some of which are below 2.5 volts, if hydrometer test, temperature, and charge data show that the cell is not fully charged; but if the hydrometer, temperature, and other data show the charge to be complete, and the cadmium gives .1 volt or more below 2.5 volts, the defective plate is determined by individual cadmium readings. When the battery is discharged—that is,

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CONSULTING DEPARTMENT—(Continued)

to 1.8 volts—the voltage between the cadmium test piece and the positive plate should be about 2.05; and between the cadmium and the negative plate, .25. The cadmium should be positive to both elements. The voltage of the cell equals 2.05 — .25 (= 1.8). If we have a cell in which the conditions tend to show full charge but the potential difference is low, a cadmium test is made. Whichever plate shows a falling off from the normal reading, that plate is the defective one.

The following precautions should be taken in making this test: It is advisable to have the cadmium plate wet before the test is made. The cadmium plate should be shaken occasionally to free it from any bubbles of gas that may form on the surface. The plate should be washed with water every time it is taken from the cell. The simplest way to accomplish this is to keep the cadmium tester in a beaker of distilled water. The cadmium should be free from impurities or foreign matter of any kind.

The surface of the metal should not be scraped bright, but it should be allowed to oxidize slightly. There is a difference of potential between cadmium and cadmium oxide; and, as the bright surface oxidizes quickly, it would be practically impossible to keep the surface bright. Care should be taken that the cadmium does not come in contact with plates or connections. This may be prevented by covering the cadmium with rubber, and perforating the covering with numerous small holes.

Hardening of Steel Tools

Question: Is it good practice to use acid baths for hardening steel tools? If not, what is a good formula?—*E. S. K.*

Answer: With acid baths, excellent results, so far as the hardened surface is concerned, can be obtained. Their use is not advocated, however, as the after effect is to rot the steel. A bath that gives excellent results is: Six quarts of soft water, one ounce of corrosive sublimate, and two handfuls of common table salt. Use when dissolved. Another formula for making tools tough and hard is: ½ teacupful salt, ½ ounce saltpeter, 1 teaspoonful pulverized alum, and 1 gallon soft water.

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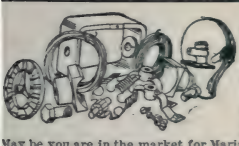

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CONSULTING DEPARTMENT—(Concluded)

White Metal Alloys

Question: Please give me the composition of the metal used for lining the cross-head slides, rod-brasses, etc.—*J. E. B.*

Answers: An alloy composed of the following is commonly used for lining the cross-head slides:

Lead, 65 parts; antimony, 25 parts; copper, 10 parts. The above is also used for rod-brasses and axle bearings. Some object to white metal containing lead or zinc. It has been found, however, that lead and zinc have properties of great use in these alloys.

In the German Navy, the following alloy is used:

Tin, 85 parts; antimony, 7½ parts; copper, 7½ parts.

Oil Filters

Question: With sponges, hay, and burlap screens placed in filter, the cylinder oil still deposits on the crowns of boilers. Kindly publish in THE TECHNICAL WORLD, a remedy for same.—*W. C. E.*

Answer: With the somewhat limited information which you have given, it is hardly possible to give a remedy for the trouble you mention. We do not know whether you are using a standard filter of some manufacturer, or whether it is a built-up filter of your own make. In any case, the only suggestion we could offer at the present is that you should renew the hay, burlap, and other substances used, whenever they become saturated with the oil. We think that in the present instance, your trouble may be due to using saturated screens.

Removing Glaze from Emery Wheels

Question: Will you please tell me how the glazing on emery wheels can be prevented?—*H. E. P.*

Answer: If the wheel is not altogether too hard, it can sometimes be remedied by reducing the face of the wheel to about ⅛ inch, or by reducing the speed, or by both. Emery wheels should be turned off so that they will run true before using. A wheel that glazes immediately after it has been turned off, can sometimes be corrected by loosening the nut, and allowing the wheel to assume a slightly different position, when it is again tightened.

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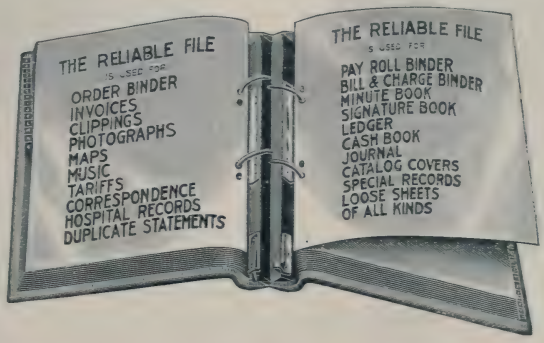

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In this connection, the following editorial, reproduced by permission of Hearst's *Chicago Evening American*, contains much food for thought:

DON'T DO JUST ENOUGH TO EARN YOUR PAY

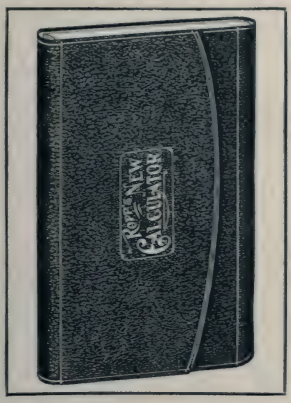
You will never get more unless you are worth it.

AMONG the young men who are fond of making sarcastic references to Fate because they have not been more successful, this expression is very common:

"I'm earning all the money I'm getting. I don't intend to do any more work than I'm paid for."

This rule a great many men follow very carefully. They estimate what they think they ought to do to earn their salaries, and they do that and no more. They feel that they are absolutely just to their employers because they are conscientious in their effort to earn exactly what is paid for.

This logic may be sound, although usually a man's estimate of what his work is worth is not very accurate; but it is about as dangerous a mental attitude as a wage-earner well can take.



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DO YOUR BEST—(Continued)

If a man is not worth more than he is getting, it stands to reason that *he will never get more.* As long as he is earning his present salary, his employers have no object in paying him one which he doesn't earn. When a man who owns a business raises a salary, he does it because he finds it profitable to himself to do so. There is very little sentiment concerned in the transaction. The employer doesn't pay a lazy man any more money in the hope to make him industrious. That hope would never be realized. He does not advance the salary of a man in the expectation that the man will be worth more to the concern. The employer knows that an expectation of that kind would be idiotic. When salaries are raised, they are raised to meet the growing value of men who are earning more than they get.

The business man knows that to keep good men working for him he must pay them according to *what they do, not* what they would do if they got more money.

In all kinds of business where men are employed, there is a large class of clerks and other wage-earners who work only for pay-day. They are continually haunted by the fear that they will do more than their neighbor who is paid the same, or that they will wear out their brains in order to make another man's fortune. They will always continue to work for pay-day, and their envelopes at the end of each week will always contain the same amount of money—or less; for when a man lacks interest in what he is doing, he soon begins to fall off in his earning power.

Meanwhile the men who keep interested, who are not afraid of doing more work than they are paid for, and who are not so much worried about wearing out their brains as they are about using them too little, are the men whose wages are advanced. Employers learn that such men steadily earn more than they are paid; and while their salaries may never keep pace with their value—there would be no profit in employing them if such was the case—they at least are progressing, and soon will leave their pessimistic young friends far behind.

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DO YOUR BEST—(Concluded)

out after success soon learns, is that when he does another man's work, he must do it better than his predecessor did. If one bookkeeper or clerk takes the place of another, he will attract no attention as long as he does the work *exactly as it was done before.* If he does not do it well, he will not be likely to last very long in his new position. But if he does it *better,* he will be noticed, and will stand an excellent chance of promotion.

In any business, ruts are soon formed, and the man who takes the place of another finds it easier to get into the same rut and plod steadily along there, satisfied if he brings down upon himself no criticism. He is usually sorrowful because he is not paid as much as the other man. He does the same work, he says, and he ought to get the same pay. But the man who is doing the paying is not looking for that kind of substitute. He is in a rut himself; and the fact that everything is going on as formerly, makes no particular impression on him. But if the new man once gets out of the rut, and does things that the man whose place he took could or did *not do,* then he begins to be noticed and marked out for advancement.

All young men are naturally anxious to earn more money—to get, somehow or other, that valuable and useful thing which is known as success. Unhappily the systems of employment in use by the great corporations limit the opportunities of vast numbers of their employees, and make it necessary for many of them to work for far less than their services are worth; but the men who *do* advance are not those who are the most careful to do only that for which they are paid. And big corporations, as well as individual employers, are alive to the value of men who *can learn to be worth more;* and that is the kind of men who get the big salaries in the end, or acquire the information and experience which enable them some day to get into business for themselves and become employers on their own account.

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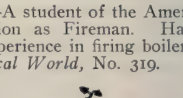

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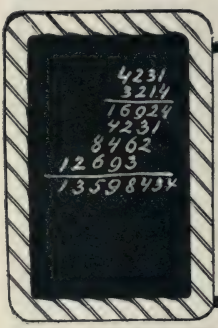

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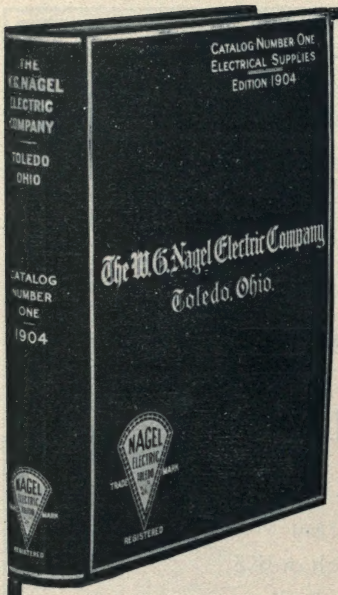

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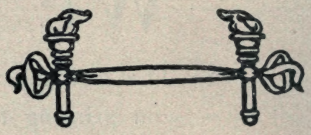

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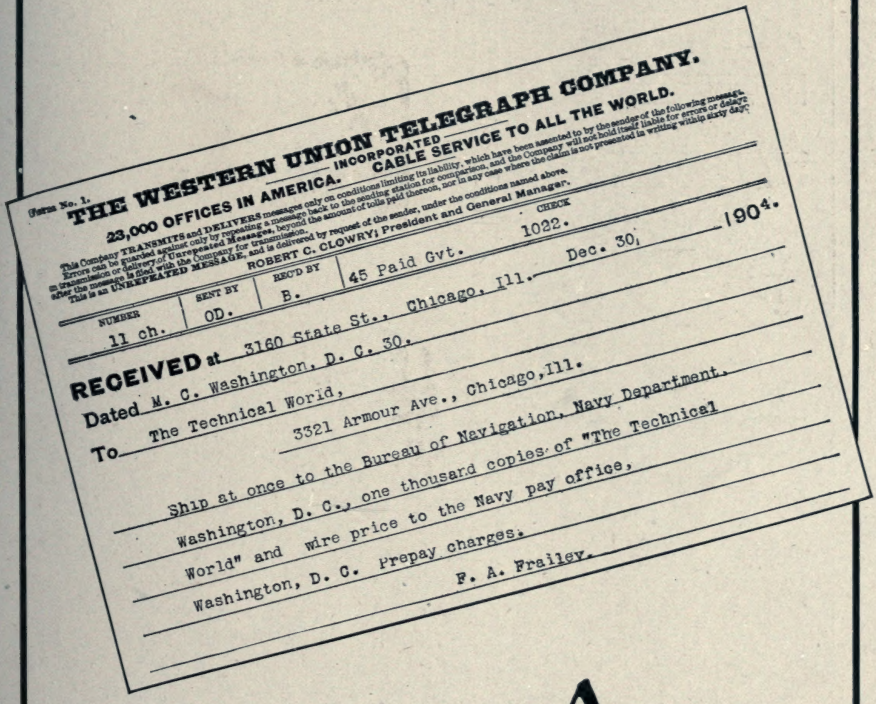

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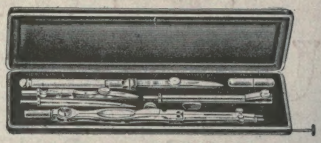

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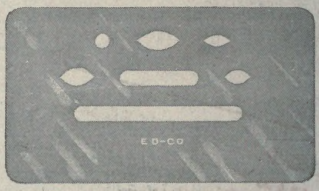

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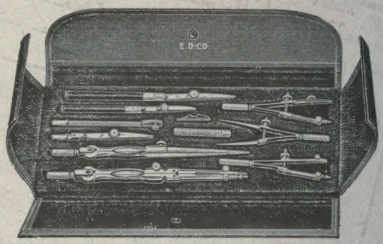

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